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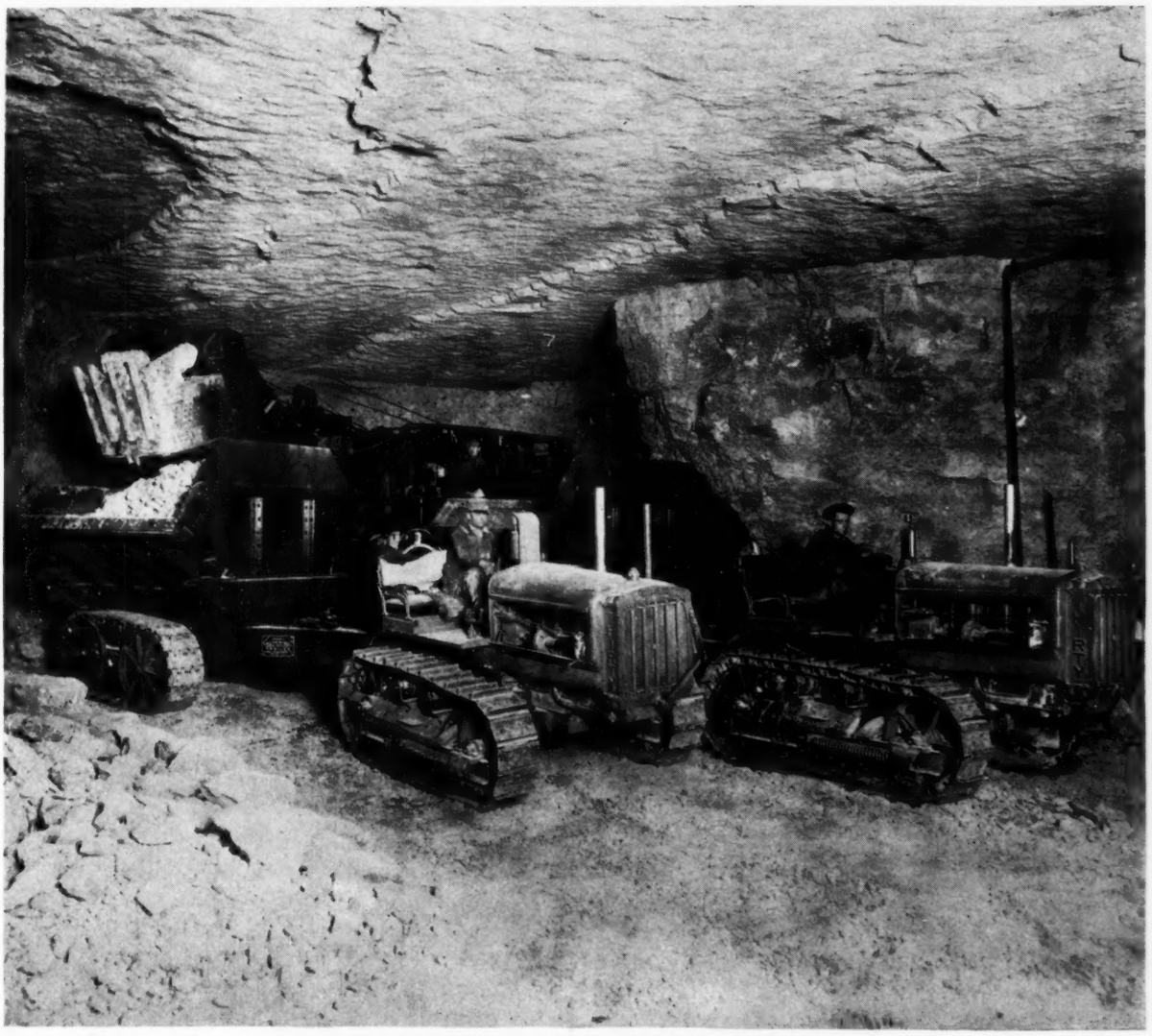

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Engineering & Mining World

A. W. ALLEN, *Editor*

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Twenty Centuries of Metallurgy Stand Back of

20 centuries ago a traveler in the mountains of Macedonia might well have stopped from curiosity to watch Greek slaves at Trepca hand-sorting ore—the only method of concentration then known. 1000 years later Saxon workmen, gathered at the same place, were engaged in recovery operations scarcely more advanced. Today, at Trepca, thanks to modern recovery methods and Cyanamid Flotation Reagents, a modern mill recovers 96.64% of lead in 75.57% lead concentrate—and 84.52% of the zinc in a 50.3% zinc concentrate.

Nor has the Trepca management stopped here. They have produced by flotation a high grade pyrite concentrate, assaying over 48% sulphur. Of this operation, the annual report of Trepca Mines, Ltd., says,"Tests were carried out both by table concentration and flotation methods, the latter proving more satisfactory."

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For 53 centuries hand-sorting was the only known method of separating lead-bearing from worthless rock. Where Trepca's mill stands today, Greek slaves monotonously and laboriously used this primitive method of concentration. "Above all, it behooves the sorters to be assiduous in their labors", said Agricola (A. D. 1550) in his comments upon metallurgy and mining in De Re Metallica. Truly it is said that with the development of flotation and modern metallurgical-chemicals this generation has witnessed greater progress in the science of concentration than the 200 generations who have extracted metal from ore since the earliest known use of lead in 3800 B.C.

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February, 1932 Vol. 133—No. 2

A. W. ALLEN, *Editor*

Additional Markets For the Mine Operator

A TREND in road building of particular significance to the metal and non-metallic mining industries is the increasing use of washed aggregate in concrete highway construction. Generally speaking, a washed gravel or crushed stone is superior to an unwashed product. Recent specifications for concrete surfacing are requiring either washed material or a material with a clay content so low that washing is necessary. The loam or clay content of a concrete, however, has been for many years the subject of much controversial discussion. For instance, information published more than a quarter of a century ago seemed to show that the addition of finely divided silica to a concrete mix resulted in an improvement in the quality of the concrete. This was explained by the fact that voids were lessened in magnitude by the silica, and a greater bonding effect was secured. Tests have also shown that the addition of a small quantity of clay may improve the quality of concrete; and lime has been used extensively to insure what is known as workability. Other experiments indicate that powdered diatomite—an opaline silica, a colloid in gel form—gives results that are superior to those obtainable by the use of clay or finely divided crystalline silica.

As already indicated, the current trend in concrete road construction is toward minimizing the amount of loam or clay in aggregate. For example, an official in charge of highway construction in one of the states of the Union, in which 1,000 miles of concrete pavement was constructed in 1931, writes in reply to an inquiry from *Engineering and Mining Journal:* "With respect to the demand for washed aggregate . . . we have finally come to the conclusion, after long experience with unwashed aggregate, that it is desirable to have it washed for pavement work." The word "pavement," as used in the United States, refers primarily to what is termed the "road" in England and in some other English speaking countries, where "pavement" is synonymous with the American term "sidewalk."

A washed aggregate, of course, commands a higher selling price than one that is not washed. But, for many operators of milling plants, the production of a washed byproduct gangue suitable for aggregate would involve little or no additional capital expense. A new and important source of revenue is therefore open to metallic and non-metallic producers. Several articles that appeared recently in this publication substantiate this view, and one operator admitted to a staff representative a few months ago that more revenue was being obtained from the sale of the then current output of coarse tailing at the property, for road-building purposes, than from the sale of metallic concentrate produced. Such a situation, all phases considered, is, of course, not normal, but it is indicative of the importance that production of a suitable concrete aggregate may have for a miner of minerals, who should investigate every possible market for his products.

Copper Industry Makes a New Stand

TWO MONTHS AGO, copper had its back to the wall. It is no exaggeration to say that, among all the leading producers of this most important nonferrous metal, only one mine, Noranda, was able to make more than ends meet at the then current price levels. Faced by a desperate situation, the copper producers have taken their medicine. With the approval of the new marketing scheme of Copper Exporters, Inc., the internal affairs of the industry have once more been set in order.

The new system reduces the pressure of the custom smelters on the New York market by giving them priority rights in foreign sales; it widens the market over which the organization has control by including export sales of fire-refined copper in the participating class; and it brings the export price more closely into accord with the New York market. All these changes are for the better. The agreement covering curtailment of production to 26½ per cent of capacity, which went into effect at the beginning of the year, also shows signs of being adapted to the situation it is intended to correct.

Copper producers have learned by experience, and they have wisely set limits to the period and the price levels within which the agreement will be effective. Although they have accomplished much, they are not yet in a safe position. Based on recent consumption rates, the surplus of copper available at refineries approximates one year's deliveries. Certainly no industry that is operating at but little more than a quarter of its capacity is in a felicitous position. The vexing problem of unemployment presents considerations that, in certain respects, are diametrically opposite to the principle of conserving the mining companies' most important resource—their ore reserves.

When a curtailment agreement was adopted in November, 1930, it was based on the then prevailing rates of copper consumption, which were low in comparison with the rates obtaining in 1929. But even the 1930 rates were high in comparison with the 1931 demand for copper, and in that failure to gage the drop in consumptive demand lies the basis for the disastrous year through which

the copper industry has just passed. For 1932, the copper producers have predicated their curtailment on the basis of shipments in August and September of 1931. If these shipments are maintained (and it is hard to see how they could be much lower), production and consumption will balance. If the shipments are increased, as all the copper producers fervently hope, then at last a genuine reduction in the huge surplus of metal will be started.

In the meantime, while the future trend of industry is still obscure and the world waits for the decisions of its political leaders, the copper industry can reflect, with some comfort, that internal dissension should not cause woe, if woe there be, during the next few months. The immediate future of copper and its price lies in the hands of the consumers, not the producers.

Simplicity and Uniformity In Technical Nomenclature

THE ADOPTION of apt, concise, and correct terms in technical literature is not usually urged because some purist is anxious to secure universal recognition and acceptance of a point of view that might be interpreted as giving evidence of a personal idiosyncracy. Many reforms in nomenclature have no significance beyond the fact that they encourage a correctness that is determined by majority usage or literary precedent, occasionally on the basis of common sense or logic.

In technical practice, a neglect to employ terms that clarify a written description, and so prevent ambiguity or misinterpretation, encourages evasion and leads to confusion. On a criterion such as this is based an evaluation of the quality of a technical article. Neglect to prevent misinterpretation can rarely be excused with justification. An example of such neglect is seen in a contemporary publication. After a summary description of the life history of diatoms, and the method of deposition of the skeletal remains, the account claims that "The deposits form the mineral known to scientists as diatomaceous earth . . ."

A protest is in order in behalf of all intelligent scientists. "Diatomaceous earth" is an unnecessarily cumbersome term. It implies physical characteristics that do not distinguish the fossilized remains of diatoms from ordinary soil; one might go further and contend, with logic, that any reference to "earth" is misleading. The substance under consideration is essentially granular; to emphasize the fact that it is neither "heavenly nor spiritual" is unnecessary. The persistent and illogical use of the term "diatomaceous earth," however, is of less significance than is the disregard engendered for correct nomenclature. Among "trade names" for "diatomaceous earth" the article then lists the word "diatomite," which is no more a trade name than is magnetite or any other mineral appelation that is recognized as correct and appropriate by standard dictionaries, as well as by Dana in his "Mineralogy." Errors of this character and their attendant complications can usually be traced to a disregard for the simple and the appropriate in technical writing. "Diatomite" is the correct term. It has the merit of geologic sanction and popular adoption, for it is found in all standard dictionaries.

Safety in Relation to Physical and Mental Health

ACCIDENTS may be classified into two main groups, according as to whether the victim is an active or a passive participant; whether the hazard is invited or facilitated by action on his part, or whether he is merely present at an unexpected and harmful happening. A piece of rock may fall on a man's head as he is walking through a stope. If his head be protected by a metal hat he will probably escape injury; if not, he may be killed. Assuming that the fall of the rock is not the result of neglect or carelessness on his part, he is merely the object of an untoward happening. He can be protected from damage by suitable apparatus.

The second type of accident is caused or accelerated beforehand by conscious or unconscious action, or neglect to take adequate precautions. The victim walks into an obstruction or a hole that he failed to notice, and breaks his leg; or he disregards a warning locomotive whistle and is run over; or his judgment is warped and his nervous system out of tune with immediate surroundings because of dizziness or ill temper. No apparatus can be relied upon to insure protection from harm under all such conditions. The man himself is the cause of the accident. His physical and mental condition must be investigated, so that the major contributory reason for the happening of the unexpected, to him, may be removed.

The majority of workers are handicapped by some physical defect that calls for adjustment by surgeon or physician. Until bodily health is restored they carry within themselves a cause for accident. Others need the attention of a psychologist before they can be trusted with the responsibility of caring for their own persons. The duty of the employer is to select wisely, and to allocate tasks within the mental and physical capacities of the applicant. As competition grows keener, the director of operations will realize that, in his own interests as well as those of his employees, constitutional defects that inhibit quick thinking, sound judgment, and rapid movement should be disclosed and corrected. Physical examinations—psychological tests, too, if practicable—are necessary preliminaries to a selection of personnel for mine or plant, to insure uninterrupted performance and normal advancement.

To insist on the provision of safe surroundings and the observance of safe practices is humane and wise; but the farseeing executive and manager will go further; he will make sure that the human machine does not contain within itself the initial cause for accident and disaster.

Air Transportation as an Economy Measure

STEADILY, albeit rather quietly, is the usefulness and application of the airplane increasing in the mining industry. Following the marked attention that this new method of transport attracted at the start, aerial conveyance of men, supplies, and equipment to remote mining fields is no longer reported as a novelty or an experiment. This indicates the settled interest being shown by many forward-looking mining executives, as

well as by the directors of commercial aviation companies, in the further utilization of airplane transportation in the industry. Air freighting of gold from the Witwatersrand to London, for instance, which has been receiving much study, is said to wait on the establishment of a suitable network of airlines in Africa, with attendant airports and emergency landing fields. Such adjuncts are required to effect material reductions in the insurance rates on gold shipments that now make air transport of bullion from the Rand economically impracticable. Opening of the London-Cape Town airline, with weekly service in each direction, recently announced, is a major step in providing the ground facilities required for regular air transport of gold and gems from Africa to England and Continental Europe.

In New Guinea, air transport of dredges and other equipment and supplies to the gold fields has proved a cheaper method than the alternative of constructing more than 45 miles of road through rugged tropical country, for the movement of the material from the seacoast. As the Managing director of one enterprise operating in New Guinea recently stated, the saving effected by use of the airplane in this instance is not readily calculable. Two years, however, would have been required to complete the road, at a heavy cost. So, besides the saving in actual freight costs, the airplane will make production of gold possible at least a year in advance of when it would have been achieved had overland movement of the equipment been employed. Owing to the magnitude of the enterprise and the richness of the fields, the interest saved on the prospective gold output for a year will probably prove to be an important amount.

Of interest also to relate is the experience of a district mining superviser of the United States Geological Survey, who uses an airplane in connection with his official duties, and who states that the cost per mile, excluding storage, of air transport in his work is less than the average cost for the govenment-owned cars operated by members of the Geological Survey.

Other instances of important economies secured by employment of airplanes in the mining industry might be cited, but sufficient evidence is available to justify the prediction that the current steady growth in the utilization of air transport for the exploitation of mineral wealth will be maintained as facts and experiences become better known.

Facing Facts

Regarding Silver

WHAT is to be done for silver? Within the last two years many scores of proposals have been made. Few of the plans are practicable; most of them are the result of faulty reasoning or inadequate knowledge of finance and trade. The space that this publication has available for economic discussions is strictly limited; to have published some of the proposals and not all of them would have invited reproof and the charge that bias was exhibited. Instead of becoming involved in a subject outside its domain, *Engineering and Mining Journal* has preferred to await the concerted action of authorities. It has been chided by critics who forget that its major duty and purpose is to stimulate improvement in the technology of mining and metallurgy. For legislative aid, and for the discussion of purely economic matters, the industry has set up other agencies.

On one occasion, however, this publication ventured to warn the silver producers of the United States that hopes should not be pinned on the efficacy of a tariff, then proposed as a panacea. Since June, 1930, nothing has been heard of legislation to this end, the absence of which from the statute books has stimulated the importation into the United States of not one single ounce of silver from the Orient. Where are those who then so stoutly maintained that a tariff wall to exclude the metal was the only protection against a "monsoon" of Indian and Chinese silver? The stand taken by this publication was based on the belief that a tariff will operate when the country levying it imports the commodity for consumption, but that a tariff will not operate when that country has a surplus of the commodity to export. However, the more recent proposals to help silver are not so simple. They range from bimetallism to the formulation of an agreement among producers not to sell at certain prices or at certain times. A few basic truths regarding silver seem of sufficient importance to be restated, with the suggestion that all who desire to improve its economic status take them into account:

1. Volume of silver production is more dependent on the prices of and demand for copper, zinc, and lead than it is on the price of silver.

2. Demand for silver comes mostly from the Orient. India and China for many years have acted as a "sponge" for silver.

3. Although the combined populations of India and China are enormous, the commercial importance of these countries, in terms of Occidental machine civilization, is much less than that of other countries with smaller populations. The total value of the foreign trade of China, for instance, is less, and for many years has been considerably less, than that of Belgium.

4. China and Mexico are the only large countries of the world on the silver standard. All other countries are on a gold-exchange basis so far as foreign trade is concerned.

5. The Oriental cannot buy additional silver from the rest of the world unless he can market the goods he produces; and, furthermore, unless he is enabled to increase production of those goods.

6. A stable silver price is a primary essential to insure extensive trading between a silver-standard country such as China and gold-standard countries.

7. The ratio of world gold reserves and world gold production to national and international commerce is higher than it has been for several years, but stocks of the metal are inequitably distributed. To improve such a condition, an unrestricted international flow of goods is necessary. To build tariff walls is to hinder trade and to delay such reform.

8. By making silver a currency metal, exchangeable at a fixed ratio to gold, the maldistribution of gold is not remedied. Under present conditions, if bimetallism were in force, silver would also tend to flow into the coffers of those countries with favorable trade balances and sound credit. Great Britain, Australia, Japan, Italy, Germany, and the Scandinavian countries, all lacking gold, do not possess large reserves of silver, nor is their silver production sufficiently large to enable them to build such reserves.

9. Concerted action among the countries of major economic importance is a necessary preliminary to the introduction of an international bimetallic standard.

Potash Recovery in Germany

Ernest R. Lilley

RAW potash salts brought to the surface from the German Zechstein mines contain practically no insoluble matter. They differ in this respect from the Alsatian and the Baden mine product. However, as the Zechstein salts contain higher percentages of soluble magnesium and sodium compounds which are more difficult to separate out, the low content of insoluble matter affords no advantages. The soluble matter is made up of a large and variable number of different minerals, most of which, however, are of minor importance.

In the German deposits, two potash minerals, carnallite and sylvine or sylvite, may be considered of major importance. Carnallite, a double muriate of potassium and magnesium with water of crystallization, was the first mineral worked and is the main source of potash in carnallite horizons. In such beds, it is invariably accompanied by sodium chloride or halite and the hydrous magnesium sulphate, kieserite. Its relative importance has decreased since the War because of the greater ease with which potash may be recovered from sylvinite horizons. Sylvinite is a mixture of sylvite, the straight chloride of potassium, and variable percentages of common salt or halite. Sylvite is also the main source of potash in "hartsalz," a mixture containing kieserite as well as common salt.

The percentage of the sulphates of potassium present in the German deposits is comparatively small. Formerly the hydrous potassium and magnesium sulphate, kainite, was used as a source of the sulphates desired by the market. Today, however, commercial sulphates are made from either sylvinite or hartsalz. Langbeinite, a sulphate differing from kainite only in lacking the water of crystallization, is of wide occurrence but of little commercial value. Polyhalite, a hydrous sulphate containing calcium in addition to the potassium and magnesium, and also known as krugite, has been worked. It is found disseminated through other salts and is the main potassium container in the beds to which it gives its name. Its low content of potash makes mining it in competition with the richer salts impossible in Germany today.

Among the less important potassium minerals present are: schoenite, leonite, rinneite, and glaserite. The greater part of the non-potassium yielding portion of the potash horizons is composed of halite, or common salt and kieserite, with variable amounts of anhydrite. Of less importance are: bischofite, tachhydrite, and astrakanite. (Note Table I.)

Table I—Common Minerals of the German Potash Deposits

	Composition	Theoretical Potash Content Calculated as K_2O
Anhydrite	$CaSO_4$	....
Astrakanite	$Na_2SO_4MgSO_44H_2O$	....
Bischofite	$MgCl_26H_2O$	....
Carnallite	$KCl\ MgCl_26H_2O$	16.9
Glaserite	$3K_2SO_4Na_2SO_4$	37.5
Halite	$NaCl$	....
Kainite	$MgSO_4KCl\ 3H_2O$	18.9
Kieserite	$MgSO_4H_2O$	....
Langbeinite	$K_2SO_42MgSO_4$	22.7
Leonite	$K_2SO_4MgSO_44H_2O$	23.3
Polyhalite	$K_2SO_42CaSO_4\ MgSO_42H_2O$	15.6
Rinneite	$3KCl\ NaCl\ FeCl_2$	34.7
Schoenite	$K_2SO_4MgSO_46H_2O$	23.5
Sylvite	KCl	63.2
Tachhydrite	$CaCl_22MgCl_212H_2O$	....

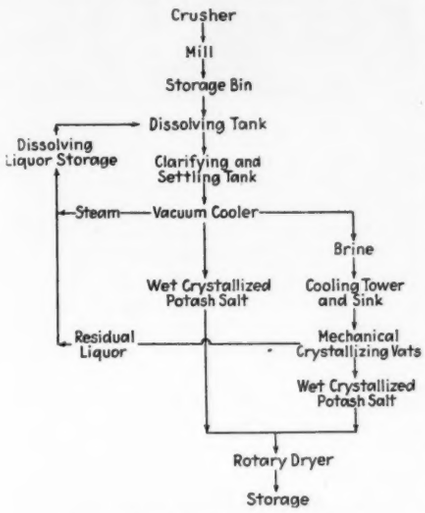
Although the percentage is decreasing, a large proportion of the potash is still sold without chemical purification. Much crude salt has always been sold mixed with sufficient refined salt to raise the potash percentage to the desired level. As potash sold raw is usually ground before shipping, the preliminary treatment of such salt differs in no way from that given the salt going into the chemical plant. The salts are dumped on a 40-mm. grizzly, from which the oversize passes to jaw crushers. Undersize and the product of the crushers pass to a hand-picking belt, from which the larger pieces of waste are removed and returned to the mine for filling. The bulk of the salt, however, passes to a series of mills of various types including coffee, beater, and roll mills, in which the salt is ground until it will pass through a 3-mm. screen.

In treating the raw salts to produce the refined products, which, because of their higher potash content, are so much preferred for shipment to overseas markets, the exact procedure employed varies somewhat with the type of raw salt available. More than half of the tonnage of potash sold in recent years is classified as potash manure salt. The types preferred are the 30 and 40 per cent K_2O grades, prepared by mixing a refined potassium muriate or chloride with crude salts. The demand for the muriate used in this way and that sold directly as muriate of 80 or 90 per cent KCl content makes the preparation of

"Mining Potash in Germany" was the title of an article by the same author in the January, 1932, issue.

potassium chloride the most important work of the treating plant. Separation of potassium chloride from its associated salts is based upon the well-known fact that it is much more soluble in hot than in cold solutions.

The simplest treatment is that of the sylvinite. Pulverized crude salt is introduced at one end of a dissolving tank, where it mixes with water just below the boiling point, pumped in at the other end. The salt is moved forward by a screw, the bulk of the potassium chloride, together with some of the sodium chloride, being dissolved, while the remainder of the latter and the less soluble anhydrite and clay are discharged at the end of the dissolver. The rich solution moves to a clarifying tank, where it remains for several hours, the suspended matter and some of the less soluble material settling out. When the potash content of the settlings warrants it, they are returned to the dissolver. In the older units, the clear and still warm solution is placed in open crystallizing vats, where it remains for two to four days, the potassium chloride and a small percentage of the sodium chloride being precipitated. The grade of product secured from the sylvinite is uniformly high, averaging from 80 to 90 per cent KCl. Higher concentrations may be obtained by rewashing. Theoretically, the process is a simple one. In practice, it becomes somewhat complicated, because of the accumulation of magnesium chloride in the dissolving liquor, this being a minor but common constituent of sylvinite horizons. As the presence of magnesium chloride in large amounts in the dissolving liquor materially reduces the amount of potassium chloride that may be dissolved, new dissolving water must be introduced at regular intervals.



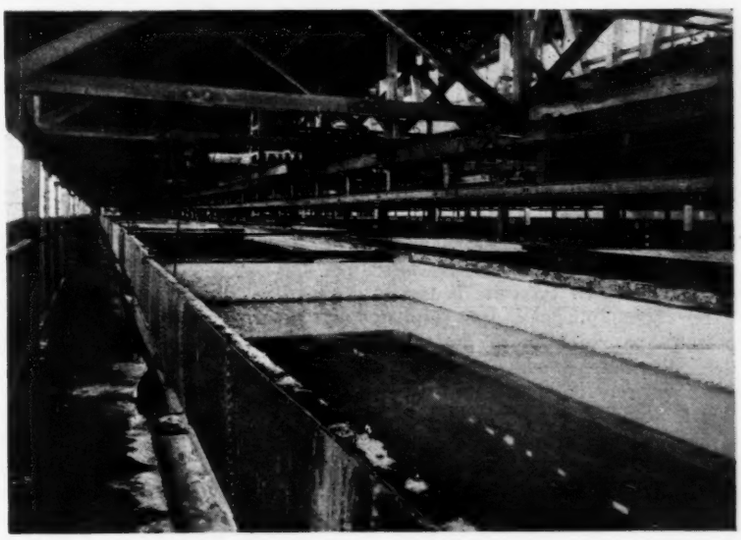
Generalized flowsheet of potash refinery

The fundamental principles underlying this process and those for the treatment of hartsalz and carnallite have not changed since the industry began. Many improvements in technic have been made, however, especially since the War, that are responsible for substantial improvement in the quality of the product obtained and in lowering the cost of purification. Better understanding of the importance of temperature and of the properties of the various soluble salts present has resulted in more definite control over operating practice. The slowness of ordinary tank crystallization, a typical batch process requiring an extremely large number of tanks and much handling of the crystallized potash, has led to numerous attempts to substitute continuous and more rapid crystallizing units. Continuous crystallizers that consist of U-shaped troughs provided with screw conveyors for removing the crystallized salts and equipped with water cooling coils and devices for bringing cold air into contact with the brine to speed up the rate of crystallization are used in some refineries.

Vacuum coolers have proved efficient in bringing about crystallization of part of the potash in the saturated solution leaving the clarifying tanks. Reduction of pressure, evaporation of part of the water of the brine, and the resulting cooling action all tend to bring about supersaturation and deposition of the potassium chloride. The brine remaining after the vacuum cooling may be sprayed into a cooling tower, the partly crystallized salt and the cooled mother liquor passing into a sink, from which they are sent to crystallizing tanks. These are supplied with devices by which the crystallized salt may be removed mechanically. Rotary filters are also used successfully for removing salt crystals from supersaturated brines. Final drying of the potash salts is done in rotary dryers.

Crude hartsalz is usually a mixture containing from 16 to 25 per cent of potassium chloride, a somewhat higher percentage of kieserite, and an average content of more than 50 per cent of common salt. The high solubility of magnesium sulphate and the ease with which it reacts with potassium chloride to form a hydrous double sulphate of magnesium and potassium make special procedure necessary in the treating of this salt. At best the product will seldom contain more than 75 to 80 per cent of potassium chloride. The solubility of kieserite increases with increase in temperature, in much the same way as that of sylvite. Rate of solution, however, is somewhat lower. In the presence of magnesium chloride, the decrease in solubility of magnesium sulphate is greater than the decrease in solubility of potassium chloride. Natural results therefore are that a solution of magnesium chloride should be substituted for clear water as the dissolving liquor, that the temperature in the dissolving tank should be slightly lower than that used in the sylvinite treatment, and that the period of contact between raw salt and dissolving liquor should be distinctly limited. The percentage of magnesium chloride in the dissolving liquor must not, of course, be permitted to approach the saturation point, as this would materially decrease the solubility of the potassium chloride also. Crystallization of potassium chloride is effected in much the same way as in the treatment of sylvinite, except that the salts crystallizing below 20 to 35 deg. C. contain only a limited amount of pure potassium chloride and relatively high percentages of hydrous double salts, which contain the chloride or the sulphate and magnesium sulphate. These are suitable for use in the lower grades of manure salts, but cannot be utilized directly in products of high potash content.

Treatment of carnallite, the first of the salts discovered and worked on a commercial basis, presents the greatest technical problems. This, together with the relatively low potash content of carnallite, is causing it to lose much of its former importance. The analysis in Table II indicates the complex character of the crude salt.



Crystallizing tanks

The crude carnallite is brought in contact with a hot solution of magnesium chloride that contains also sodium chloride, potassium chloride, and magnesium chloride. Insoluble matter, kieserite, and the bulk of the common salt remain undissolved and are removed. The high degree of solubility of the magesium chloride and the decrease in the solubility of the potassium chloride in its presence make necessary the use of large quantities of dissolving liquor. Theoretically, the hot solution can contain

Table II—Analyses of a Typical Crude Carnallite

CHEMICAL ANALYSIS

Constituent	Per Cent
KCl	15.7
NaCl	21.5
MgCl (including 0.2 per cent $MgBr_2$)	21.3
$CaCl_2$	0.3
$MgSO_4$	13.0
H_2O	26.2
Insoluble	2.0
	100.0

MINERALOGICAL ANALYSIS

Constituent	Per Cent.
Carnallite	58.4
Halite	21.5
Kieserite	15.0
Tachhydrite	1.5
Bischofite	1.6
Clay, anhydrite	2.0
	100.0

up to 249 grams of magnesium chloride, 33 grams of potassium chloride per liter, and also some magnesium sulphate and sodium chloride. As it is evaporated and cooled, an artificial carnallite, with some sodium chloride, crystallizes out, leaving an almost pure magnesium chloride residual liquor. Best results are obtained in practice when the potassium chloride content is not reduced below 10 to 15 grams per liter. The product obtained directly from the carnallite will contain about 60 per cent KCl when wet and yields a 40 per cent manure salt when dried. Rewashing of the artificial carnallite improves the quality of the product, especially through reduction of the content of sodium chloride.

In a typical plant, from 12 to 15 per cent of the potash content of the raw salt remains unrecovered. The inability to secure a better recovery or to produce a high quality of product without numerous rewashings has led to the development of several variations from the process outlined, but, as none have brought material advantages, the cost of producing refined salts from crude carnallite remains higher than the cost of producing them from the more recently developed sylvinite beds.

For some purposes the sulphates of potash are much more desirable than the chlorides. Today, such salts are made entirely from the chlorides. The double sulphate of potash and magnesia is produced cheaply by interaction of potassium chloride and kieserite, according to the following equation:

$$2KCl+2MgSO_4+6H_2O \leftrightharpoons K_2SO_4.MgSO_46H_2O+MgCl_2$$

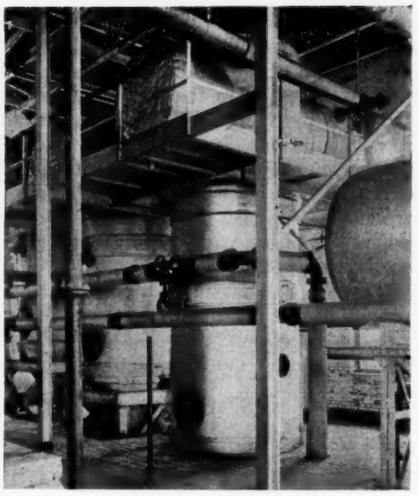
A large portion of this double sulphate may be crystallized from the resulting solution at between 30 and 40 deg. C. If the precipitated double sulphate is redissolved and brought in contact with additional chloride of potassium, the straight sulphate of potassium will be obtained, according to the following equation:

$$K_2SO_4.MgSO_4+2KCl \leftrightharpoons 2K_2SO_4+MgCl_2$$

The types of products demanded by the fertilizer trade, the most important consumer of potash salts, are produced directly from raw salts, or from refined salts, or by mixing refined and raw salts. The determining factor is that of meeting the specification for potash—the K_2O content. Market carnallite, a grade made largely from crude salt with little or no addition of refined salts, contains only from 9 to 11 per cent of K_2O. This and market kainite-hartsalz and crude sylvinite, containing 12 to 15 per cent of K_2O, are sold largely in Germany. The lower grade of manure salts, known as the 20 and 30 per cent grades, contain from 18 to 22 per cent and 28 to 32 per cent of K_2O, respectively. These are usually prepared by mixing raw and refined salts. The higher grade salts, 40 per cent manure salt, 50 per cent manure salt, or muriate of potash, sulphate of potash-magnesia, and sulphate of potash, the chief types sold to the overseas trade, are composed largely of refined salts.

In addition to producing fertilizer salts, the potash industry produces high-quality potassium compounds for chemical purposes. Some plants produce a full line of sodium and magnesium salts. A few recover and sell the bromine. Several are directly interested in oil production, one in particular now securing substantial quantities of oil from shallow wells drilled into the formations immediately underlying the potash beds. Important as these sources of income are, the revenue that is secured therefrom is only a small proportion of that obtained through the sale of the fertilizer salts.

Prices quoted on fertilizer salts vary widely, because of the differences in the percentages of K_2O present. The price f.o.b. works of ordinary kainite has averaged about 20c. a short-ton unit since the close of the War. Quotations on the sulphate have averaged about four times as much. Discounts from quoted prices are allowed, especially on large quantities and out-of-season deliveries, but the prices actually paid do not appear to be much lower than those quoted. Prices quoted for delivery in foreign



Vacuum coolers

consuming centers are naturally higher than those quoted for domestic delivery. Examination of the financial statements of the various concerns operating in the potash industry indicates that the cost of production and marketing for the industry, as a whole, averages but little below the selling price and has permitted only moderate returns on the total amount of capital that has been invested in the industry.

In comparison with the French-controlled Alsatian mines, German production and marketing costs appear to be high and profits low. Although the French enjoy certain advantages over their competitors because of the simple chemical character and high potash content of their raw salts, these are probably more than balanced by the greater ease of mining the German salts and the wider range of products that can be produced from them. The French operate mines taken over from Germany at the close of the War; they are most conservatively capitalized. Although the French organizations have made heavy investments in new mining and treating equipment and in housing facilities since the War, the capital investment is comparatively low, and the proportion of the gross income consumed by fixed charges is insignificant.

In Germany the reverse is true. Speculation following the enormous profits of some of the concerns first entering the potash business led in the years immediately previous to the War to the development of productive capacity far beyond the possible needs of the market. The condition became fully apparent as early as 1910, when a number of new shafts were still in the sinking stage. Conditions became chaotic at the close of the War, with the loss of the Alsatian

Table III—Analyses of Market Grades of German Potash, Per Cent

Product	K_2SO_4	KCl	$MgSO_4$	$MgCl_2$	NaCl	$CaSO_4$	Insoluble	H_2O	K_2O
Kainite-hartsalz	0–4	19–24	0–32	0–8	29–77	0.2–6	0.5–20	0.2–16	12–15
40 per cent manure salt	0–9	60.1–66.4	0–10	0–6	16–33	0.2–6	0.2–6	0.2–6	38–42
50 per cent manure salt (muriate of potash)	0–3.5	79.1–85.4	0–5	0–3	10–16	0.1–4	0.2–3	0.2–5	50–54
Sulphate of potash-magnesia	48.1–55.5	0–3.0	25–38	0–1.5	1.0–4	0–6	0.2–13	4–10	26–30
Sulphate of potash	89.0–96.0	0–4.5	1.5–4.5	0–1.5	0.5–4	0.5–4	0.2–2	0.3–3	48–52

mines to an unfriendly nation and the financial collapse of Germany. The government took most drastic measures to reestablish the industry on a sound basis. It set up a governing organization, the Reichs-Kalirat, to supervise the activities of the industry in the interests of the people of Germany, the industry assuming a position resembling in many ways the position occupied by the railroads and the public utilities in the United States. Secondly, it forced the potash companies to become members of an organization called the Kalisyndikat, through which the entire production of the potash salts was to be sold. Each plant was assigned a quota based upon its productive capacity. Except for several mines nearing completion, the sinking of new shafts was prohibited until 1953.

Competition among the various German producers automatically ended, and the weaker high-cost producers gained a new lease on life. The larger and stronger companies were able to shut down some of their less efficient units and produce entirely from the newer and more efficient. In providing quotas for all plants, however, the quotas assigned to individual plants were limited to such an extent that no mine could, even by adding the quotas of mines associated with it, operate at full capacity. Furthermore, none of the mines were in a position to benefit by the introduction of new, efficient, cost-reducing equipment.

The stronger companies began to absorb the weaker ones, to obtain their quotas. However, although the mines taken over could not be operated on an economically sound basis, their quotas could be utilized without making substantial royalty payments prescribed by the law of 1919. Expenditures made in securing quotas were of necessity capitalized. This process of centralization of quotas in the hands of a relatively few large concerns was further extended as a result of the better feeling concerning the future, arising from the 1924 agreement with the French that limited competition in foreign markets. To take advantage of economies possible through the use of more modern equipment and to reimburse themselves for part of their expenditure in securing additional quotas, the large producing companies and the Kalisyndikat joined in borrowing about $60,000,000, in the form of 7 per cent bonds, in England. As a result of this, and failure to write down capitalization to conform to conditions resulting from the closing of units no longer economically workable, the German potash industry is today badly handicapped by its fixed charges. If the recent boom period had lasted a few years longer, the fixed charges would have been greatly reduced, and the German industry would have been able to extend its markets materially by lowering its prices, and yet, because of increasing ability to lower operating costs, to have increased its net profits.

■ ■ ■

Blasting in Seismic Work

THE cardinal principle of shot planting in commercial seismology is to plant the powder as deep as time, terrain, and costs will permit. A method commonly used employs a hand-drilled borehole. This is bored 4, 5, or 6 in. in diameter to a depth of from 12 to 25 ft. A small cavity is then blown at the bottom with from 4 to 8 lb. of dynamite. The entire charge of several hundred pounds is then placed in the cavity and the hole tamped with dirt or water. This type of loading, however, does not prevent the blowing out or cratering of the hole on exploding the charge.

In marsh work, where hand-drilled holes are impossible, very large cartridges, about 8x24 in., are usually employed. These are forced with a wooden tamper as deeply in the soggy muck as possible. On the open water the desired charge is sacked and primed, and the bags are lashed together and tossed overboard at the given location.

A recent innovation in shot planting, according to the Atlas Powder Company, is the use of a portable rig for drilling holes from 60 to 100 ft. deep and lowering the charge in torpedo-shaped cans. These holes do not crater and can be used repeatedly, although to use them over five or six times is not wise. In Gulf Coast country, these holes are rotary drilled; in West Texas and Oklahoma, where the formations are harder to drill, a small cable tool outfit is necessary.

In calculating the desired charge for loading a deep hole, the accompanying table will be useful. It shows the quantity of explosives per foot, for containers of different diameters, on a basis of 87 lb. per cubic foot for gelatins and 77 lb. per cubic foot for dynamites, the cartridge wrappers being slit and the containers well tamped.

The time required and cost operate against the deep-hole method, although it has been and is being largely used. To drill holes costs from 50c. to over $1 a foot, depending chiefly on whether the company does the drilling or contracts it, the latter as a rule being the more costly. Owing to the complete utilization of the explosive energy in producing earth shock, dynamite charges for deep holes give more effective results with only one-third or less dynamite than required for shallow or hand-drilled holes.

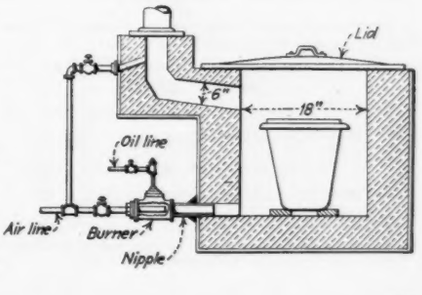
Blasting Charges

Diameter of Container, In.	Cubic Feet per Foot of Container	Approx. Pounds Gelatin per Foot	Approx. Pounds Dynamite per Foot
1	0.00545	0.47	0.42
1¼	0.00852	0.70	0.65
1½	0.01227	1.07	0.95
1¾	0.01668	1.45	1.3
2	0.02182	1.8	1.7
2½	0.0341	2.8	2.6
3	0.0491	4.3	3.8
3½	0.0668	5.8	5.1
4	0.0873	7.15	6.7
4½	0.1104	9.6	8.5
5	0.1363	11.9	10.5
5½	0.1650	14.3	12.7
5¾	0.1722	15.0	13.3
6	0.1963	17.1	15.1
7	0.2672	21.9	20.6
8	0.3490	30.3	26.9
10	0.5454	47.4	42.0

■ ■ ■

Oil-Fired Brass-Melting Furnace

THE efficiency of a brass foundry depends to a large extent on the type and construction of the melting furnace used. A properly designed furnace means rapid smelting of the charge, a superior grade of brass, and economies in fuel and labor. To attain these objectives, R. S. Livingston, master mechanic of Uvalde Rock Asphalt Company, Blewett, Tex., developed the simple and inexpensive oil-fired furnace shown in the accompanying illustration. The welded ⅛-in. sheet-iron shell and the burner were made entirely from scrap material. Standard firebrick was used for lining. The burner consists of a 2-in. tee with a short pipe nipple, connected by reducers to the 1-in. air line, and to the ⅜-in. oil line. Oil fed by gravity is atomized and blown into the combustion chamber by the injector. The 1-in. air connection on the flue end of the furnace serves to control the draft. A heavy iron lid on the melting chamber reduces heat losses.



COST OF RAISING

Morris J. Elsing

MUCH greater variation occurs in the cost per foot of raising than in drifting. The reason for this is the difference in style and character of raises, especially in methods of timbering.

In general, raises can be divided into five types. The cheapest is the small one-compartment, untimbered rock raise, usually 4.5x4.5 or 5x5 ft. The next cheapest raise is the two-compartment rock raise, the timber in which consists of a dividing line of stulls to which lining boards are fastened. This type of raise is about 5x8 ft. in cross-section. When untimbered it gives a chute compartment 4x5 ft. and a manway 3x5 ft. The third type is the small cribbed raise, usually of two compartments, each about 3x3 ft. in the clear. The ground to be removed in this raise is about 4.5x8 ft., which corresponds in size to the stulled raise. The square-set raise is a fourth type; the large, heavy cribbed raise is a fifth type.

The cost of driving a two-compartment rock raise is similar to the cost of driving the average drift. Cross-sections are similar; and, therefore, the material to be removed is equal. The raise requires more holes; consequently, drilling costs per foot are slightly higher than in drifting. The powder used in raises per foot is a little less than in drifts of equal cross-section.

In raising, the only mucking necessary is at the start of operations. On the other hand, the raise has an added cost for timber and for the hoisting and placing of timber. The cost per foot of a two-compartment rock raise with stulls and lining is slightly less than that of a drift of the same character.

An economical and satisfactory raise is the small two-compartment cribbed raise made from 3x12-in. cribbing. The amount of ground removed is slightly less than in the two-compartment stull raise. Timber is easily put in, and can easily be removed in the event that one

One of a series of articles on the cost of mining in the United States.

Table I—Types of Raises

Type	Class	Cross-Section, Feet	Timber
I	1-Compartment, rock	4½ x 4½	Stulls
II	2-Compartment, rock	5 x 8	Stulls and lining
III	2-Compartment, cribbed	4½ x 8	3- and 12-in. cribbing
IV	2-Compartment, square-set	7 x 12	Square-sets
V	2-Compartment, cribbed	6 x 11	5 x 8-in. cribbing

Table II—Timber Requirements

Type of Raise		Character of Timber	Board-Feet per Foot
I	Single-compartment, rock	Stulls (removed after driving)	8
II	2-compartment, rock	Stulls and lining, miscellaneous	33
III	2-compartment, cribbed	Cribbing, lining, miscellaneous	78
IV	2-compartment, square-set	Sets, lining, lagging, miscellaneous	
		8 x 8-in. timber	119
		10 x 10-in. timber	152
		12 x 12-in. timber	192
V	2-compartment, cribbed	5 x 8-in. cribbing, lining, miscellaneous	220

Table III—Glory-Hole Raise, Fresnillo, Mexico

	Cost per Foot	
Drilling	$7.92	
Timbering	0.84	
Explosives	1.79	
Loading and tramming	0.86	
	$11.41	
Total cost, labor and bosses		$8.16
Supplies		2.92
Power		0.33
		$11.41

A.I.M.E., Vol. 72. Formation, graywacke and shales. No hoisting; rock raises, 10 ft. diameter; no timber.

Table IV—Raise in Pilares Mine, Sonora, Mexico

Pilot Raise Labor	Cost per Foot
Breaking	$2.45
Mucking	0.67
Supplies	0.08
Drills and tools	2.32
Explosives	1.92
Timber	0.33
Total	$7.77

I.C. 6307. Raise 4x7 ft. untimbered. Latite and andesite. Apparently, cost of tramming, hoisting, and indirect labor not charged, which, if added, would bring cost to between $10 and $11 per foot.

Table V—Raise in Iron Cap Mine, Globe, Ariz.

	Cost per Foot
Labor	$4.78
Explosives	2.19
Timber	1.82
Air	2.42
Miscellaneous	0.45
Total	$11.66

A.I.M.E., Vol. 72. Only the manway is timbered with "clap-me-down" sets; raw chute.

Table VI—Cost of Raising at United Verde Mine, Jerome, Ariz.

Example 1.

	Massive Sulphides	Schist	Quartz Porphyry
Labor, miners	$15.70	$6.27	$3.31
Miscellaneous	1.64	1.55	0.65
	$17.34	$7.82	$3.96
Explosives	5.28	3.26	0.99
Timber	2.05	1.63	0.92
Supplies	0.52	0.20	0.12
Repairs, drill, and steel	4.35	1.79	0.63
Compressed air	4.60	1.90	0.66
	$34.14	$16.60	$7.28
Depth of hole, ft.	4.3	6.0	8.0
Number of holes	18	15	12
Distance drilled per round-foot	77	90	96
Distance drilled per machine-shift	11	28	48
Advance per round	3.4	5.1	7.4
Cross-section, ft.	6x11	6x11	6x11

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Example 2.

	Cost per Foot
Labor	$11.93
Explosives	3.01
Timber	4.07
Compressed air	0.93
Repairs	2.55
Supplies	0.42
Total	$22.91

M. C. J., Sept. 1927. Average cost of raising, 1926.

Example 3—*Raising No. 5 and 6 shaft.*

	Cost per Foot—No. 5 Shaft	No. 6 Shaft
Section excavated	7 x 17 Ft.	14.3 x 14.3 Ft.
Labor	$12.91	$23.88
Explosives	3.08	5.14
Timber	2.60	3.85
Compressed air	4.20	2.62
Supplies and repairs	6.20	5.28
Totals	$28.99	$40.77
Average depth of hole, ft.	5.5	5.5
Advance, ft.	4.25	4.75

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Table VII—Cost of Raising in Alaska Gastineau Mine, Juneau, Alaska

	Slate	Schist	Gabbro
Labor	$5.16	$6.99	$5.82
Power	0.21	0.27	0.28
Superintendence and general expenses	1.54	2.16	2.00
Store expense	0.27	0.24	0.24
Tramming labor	0.24	1.58	0.79
Tramming	....	....	0.04
Machine-drill expense	0.90	1.87	1.24
Explosives	1.53	2.42	2.08
Carbide	0.03	0.08	0.05
Timber	0.64	0.43	0.49
Other stores	0.02	0.09	0.03
Totals	$10.54	$16.13	$13.06

A.I.M.E., Vol. 63. Firm ground, 5 x 8 ft. cross-section, 60-deg. incline, no timber except 4 x 6-in. stulls and 2 x 12-in. lagging. Known as manway raise.

desires to make a large ore-transfer raise. To drive such a raise is safer, because the men work on securely placed timber, and never on stulls with plank resting upon them. To make a good fit between the outside plank and the rock walls of a stull raise is difficult. This means a dirty raise, as fines always leak into the manway compartment. This is avoided when cribbing is used. If the lining is not used in the cribbed raise, 24 bd.ft. of timber can be saved per foot of raise. This will reduce the timber requirements to 52 bd.ft. per foot, as against 33 bd.ft. used in the stull raise. It is an ideal prospect raise in hard ground; if no ore is found, the cribbing can be economically removed and used again. It is an efficient and economical raise in soft ground in mining by top-slicing, and it has many other uses.

The square-set raise is costly, on account of the amount of timber used and the cost of placing the timber. At 4c. per board foot of framed timber, the timber cost of a square-set raise with 8x8, 10x10, and 12x12-in. timber is $4.75, $6.08, and $7.68 per foot, respectively. In addition to this, to hoist the timber for a two-compartment raise and block it, to lag the raise and line the chute, is more than a day's work for two men. The 5x8-in. large cribbed raise requires slightly more timber and is equally costly.

Little information is available regarding the cost per foot of driving raises. The costs presented in the data included herewith are not all representative, but they are the best now obtainable. In most instances where costs for two-compartment raises are less than $12 per foot, they are incomplete, as is apparent by the items missing in the charges made. Indirect labor, a large item, includes superintendence, caging, hoisting, top landing, waste disposal, installation and maintenance of air, water, and ventilating

Table VIII—Davis Daly, Butte, Mont.

	Raising Octagonal Shaft Cribbed With 8x10-in. Timber, Cost per Foot
Total labor	$14.76
Explosives	2.327
Compressed air	0.857
Rock drill repairs	0.691
Steel consumption	0.386
Steel sharpening	0.279
Timber	11.077
All other supplies	0.331
Total	$30.71

A.I.M.E., Vol. 66. Octagonal shaft 8x10-in. timber cribs 6 ft. 6 in. in the clear; 10-ft. circular rock dimensions; 3-ft. advance per shift. Timbered close to back; 1,607 ft. of raising. Powder cost 20c. per pound. Timber, $37 per 1,000 bd.-ft. All other supplies include pipe later reclaimed. Labor cost includes $3 per foot for extra work in catching up caving or heavy ground. A charge of $1 is included for tearing out chute lining. Cost does not include hoisting. Year 1921.

Table IX—85 Mine, Valedon, N. M.

	Cost per Foot
Labor	$8.60
Explosives	2.97
Timber	0.82
Air drills	5.05
Other supplies	0.11
Total	$17.55

I.C. 6413. Two-compartment stull raise in quartz. Direct costs only.

Table X—Average Cost Raising in Large Arizona Mine, 1931

Labor	Cost per Foot
Direct	
Drilling	$3.50
Tramming	1.00
Timbering	2.50
Indirect labor	3.60
Insurance	
Explosives	2.05
Timber	5.75
Drill-steel, expense, drill repairs, power, miscellaneous supplies	2.45
Total	$20.85

Indirect labor includes caging, hoisting, top landing, and tramming at waste dump.

Standard two-compartment square-set raise, using 10x10-in. timber. Ground medium hard.

Table XIII—Summary of Cost of Raising

Location	Reference	Size, Feet	Cost per Foot	Remarks
Engels, Calif.	I.C. 6260	6x8	$18.34	Hard; 20 per cent timbered, 1929; diorite
Alaska Juneau	A.I.M.E Vol. 72	5x10	13.33	Stope raises; contract price $6–$8; 1925
Iron Cap, Globe, Ariz.	A.I.M.E. Vol. 72	5x10	11.66	Chute raise; 1925; direct costs
Mogollon, N. M.	A.I.M.E. Vol. 72	5x10	14.08	Andesite and rhyolite; 1922
Latouche, Alaska	A.I.M.E. Vol. 76	4½x4½	8.56	Chute raises; 40 deg. dip
		5x5	8.98	Raise to stope
		5x5	8.10	Mining 55–70 deg. incline
			9.55	Prospect
			14.01	Ventilation. Slate, graywackes, schist. Total charges
Miami Copper, Arizona	A.I.M.E. T.P. 314	4½x4½	8.49	Inclined 55 deg. untimbered; 1925-1928; schist
United Verde, Jerome, Ariz.	A.I.M.E. Vol. 66	6x11	34.14	Massive sulphides; 1918
		14.3x14.3	40.77	Raising No. 6 shaft; 1918
		7x17	28.99	Raising No. 5 shaft; 1918
		6x11	16.60	Schist
		6x11	7.28	Quartz porphyry
Alaska Gastineau	A.I.M.E. Vol. 63	5x8	10.54 (Slate)	Sixty-degree incline; no timber except stulls and lining; firm ground; 1929
		5x8	16.13 (Schist)	
		5x8	13.06 (Gabbro)	
Davis Daly, Butte, Mont.	A.I.M.E. Vol. 66	Circular 10	30.71	Raising shaft 1,607 ft.; 8x10-in. timber; cribbing; hoisting not included; 1918
United Verde, Jerome, Ariz.	M.C.J. Sept. 27	6x11	22.91	Average cost; 1926
Fresnillo, Mex.	A.I.M.E. Vol. 72	10x10	11.41	No timber; no hoisting; shale and graywacke; 1925
Pilares, Mex.	I.C. 6307	4x7	7.77	Direct costs; no timber except stulls; latite and andesite; 1929
Giroux, Kimberly, Nev.	A.I.M.E. Vol. 41	14x21	63.71	After credit of $7.50 for recovered timber; limestone; shaft raise
85 Mine, Valedon, N. M.	I.C. 6413	....	17.55	Two-compartment stull raise in quartz; direct costs
Morenci, Arizona	I.C. 6107	7x7	7.63	Pilot raise; estimated
Pecos, N. M.	I.C. 6368	4x6	12.74	Two-compartment stull raises; 1929; some winzes.
			12.49	1927-1929. Some winzes.
Hanover Bessemer, Fierro, New Mexico	I.C. 6361	7x10	5.48	Direct costs; development raises; 1930
Arizona Mine	Person	7x14	20.85	Total costs square-set raise; 10x10-in. timber; medium ground; 1931
Old Dominion, Globe, Ariz.	Person	6x11	20.79	Total cost large cribbed raise; medium ground: 1931
U.V.X., Jerome, Ariz.	Person	7x12	25.32	Total cost square-set raise, hard ground; 1931
		7x12	17.96	Ditto, medium ground
		5x9	16.56	Small cribbed, hard ground.
		5x9	12.28	Medium ground; 1931
Mine No. 1, Menominee, Mich.	I.C. 6180	5x5	4.25	Contract price for labor and explosives
Block P, Hughesville, Mont.	I.C. 6416	4½x7	5.00	Contract price for labor and explosives; shaft timber
Matahambre, Cuba	I.C. 6145	5x5	4.57	Contract price for labor and explosives
Park Utah, Park City, Utah	I.C. 6290	5x8	3.00	Incomplete labor cost
Black Rock, Butte, Mont.	I.C. 6370	8x14	10.08	Contract labor 8c. to 10c. per cu.ft., square-set raise
Ground Hog, Vanadium, N.M.	I.C. 6377	4x7	1.75	Labor, drilling, and blasting only; stulls
Mine No. 1, Picher, Okla.	I.C. 6113	6x6	3.50	Drilling labor only
Rosiclare, Rosiclare, Ill.	I.C. 6384	5x8	5.00	Contract price for labor and explosives
Alaska Juneau	I.C. 6186	5x5	7.50	
		7x7	11.00	Contract price for labor and explosives. Ditto
U.V.X., Jerome, Ariz.	Person	7x12	7.50	Square-set; contract price for labor and explosives
		5x8	4.00	Cribbed raise; contract price for labor and explosives

pipe, track and car maintenance, as well as numerous other minor items. Nearly a dozen small items, called indirect supplies, are seldom charged directly to raising. These include carbide, water, machine-drill oil, car grease or oil, and so forth. In the aggregate these are appreciable charges.

In the costs of raises given herewith the following abbreviations are used: I. C., U. S. Bureau of Mines Information Circular; A.I.M.E., "Transactions" of the American Institute of Mining and Metallurgical Engineers; M.C.J., *Mining Congress Journal.*

An attempt is herewith made to set an average cost per foot for driving each type of raise mentioned. These costs are for medium-hard ground. The assumption is that the muck is hoisted and that the prices of explosives, power, and timber are normal. The costs given herewith are for vertical raises 100 ft. or less in height.

Table XI—United Verde Extension, Jerome, Ariz.

Cost of Square-Set Raises

	Cost per Foot	
	No. 1	No. 2
Breaking and timbering	$8.14	$6.99
Tramming	2.86	1.77
Timbers	4.90	5.25
Explosives	3.76	1.20
Air-drill expense	4.62	1.98
Overhead	1.04	0.77
Total	$25.32	$17.96

Raise set posts are 5-ft. 6-in. center to center rather than the more usual 5-ft. interval. Timbers are 10x 10 in. Costs shown under heading No. 1 are for an inclined square-set raise in hard ground. Costs under heading No. 2 are the average of the raises driven in medium hard ground. Raises are of two compartments.

Cost of Cribbed Raises

	Cost per Foot	
	No. 1	No. 2
Breaking and timbering	$8.15	$5.65
Tramming	1.44	1.66
Explosives	2.25	1.32
Timbers	0.97	1.42
Air-drill expense	2.80	1.51
Overhead	0.95	0.72
Total	$16.56	$12.28

Raises are of two compartments with raw chute. Manway compartment is 3-ft. 6-in. inside timbers. Cribbing is 3-in. By carrying the chute raw, an estimated saving of between $2 and $3 per foot is made. Costs under heading No. 1 are the average of driving two raises in hard ground. Costs under heading No. 2 are the average for three raises for medium hard ground.

Table XII—Old Dominion Company, Globe, Arizona

Labor	Cost per Foot
Drilling (breaking)	$2.29
Tramming	1.10
Timbering	2.28
Indirect, caging, hoisting, top landing, waste disposal, supervision, miscellaneous and surveying	3.16
Insurance (state compensation)	0.10
Timber	6.20
Explosives	2.10
Drill-steel expense	1.82
Drill repairs	0.05
Power (compressed air)	1.55
Miscellaneous supplies	0.14
Total	$20.79

Estimated cost of driving a two-compartment raise each compartment 4 ft. 4 in. in the clear, cribbed with 5x8-in. cribbing and the chute compartment lined with 2-in. plank; medium hard ground; 1931.

Table XIV—Estimated Cost of Raising

	I	II	III	IV	V
	Rock, 4½x4½-ft. 5x5-ft.	Stull, 5x8-ft.	Small, Cribbed, 4½x9-ft.	Square-Set, 7x12-ft. 10x10-in. Timber	Large Cribbed 6x11-ft. 5x8-in. Timber
Labor					
Direct					
Drilling	$1.90	$2.50	$2.50	$3.25	$2.80
Tramming	0.40	0.65	0.60	1.35	1.05
Timbering	0.30	0.60	0.80	2.50	1.90
Indirect labor	1.75	2.25	2.25	3.85	3.20
Insurance	0.13	0.18	0.18	0.35	0.25
Explosives	1.40	1.90	1.90	2.30	2.15
Timber	0.24	1.32	2.12	6.08	8.80
Drill-steel expense	0.50	0.70	0.70	1.30	1.20
Drill repairs	0.35	0.50	0.50	0.80	0.75
Power	0.50	0.75	0.75	1.40	1.20
Miscellaneous supplies	0.60	0.75	0.75	0.95	0.95
Totals	$8.07	$12.10	$13.05	$24.13	$24.25

The great differences in costs per foot of driving raises as shown in Table XIV explains why so great range of costs is shown in Table XIII.

One-compartment, 4- or 5-ft. raises without timber are driven at Latouche, Alaska, and Miami, Ariz., for $8.50 to $9 per foot. Raises 5x8 ft. in cross-section are driven at the Alaska Juneau and Alaska Gastineau for from $10.50 to $16 per foot—an average of $13.25 per foot. Two-compartment stull raises are driven at Pecos, N. M., for $12.74 per foot. Small cribbed raises with a raw chute are driven at the United Verde Extension for $12.28 per foot. Two-compartment square-set raises are driven at this mine for $17.96 per foot in medium ground, and for $25.32 in hard ground. Two-compartment square-set raises are driven for $20.85 per foot at another large Arizona mine; and large cribbed raises are driven at the Old Dominion for $20.79 per foot. The average raise cost for 1926 at the United Verde mine, where large cribbed raises are generally used, was $22.91 per foot.

The actual costs cited for the square-set and large cribbed raises are somewhat lower than the estimated costs. This is caused by the difference in the amount of timber used. The estimated cost included complete lagging, lining, and blocking. In actual practice, raises are often driven without the total calculated timber, and this accounts for the difference between the actual costs and those estimated.

In general, in driving square-set raises, the labor for breaking and for timbering is 60 and 40 per cent of the labor cost, respectively; although one company reports that these costs are about equal. One company, also, reports that 50 per cent of the labor is for breaking and 50 per cent for timbering in driving large cribbed raises. Another company reports that driving small two-compartment cribbed raises with raw chutes, 80 per cent of the labor is required for breaking and 20 per cent for timbering.

Table XV—Summary Estimated Cost of Raising

	Cost per Foot
Small one-compartment, rock	$8
Two-compartment, rock	12
Small cribbed two-compartment	13
Two-compartment square-set	24
Two-compartment large cribbed	24

Sharpening Ten Thousand Drill Steels Per Day

Drill-steel sharpening — an all-important factor in drill-steel economy—as employed on the Witwatersrand is described in detail in this article. The magnitude of operations is indicated by the fact that, to handle from 10,000 to 11,000 drill steels per eight-hour working day, nineteen sharpening machines are required; and the weight of drill steel in use at the face, in transit, and in the shop totals 170 tons. Tempering is performed under accurate control, a special color-matching device, described in a recent issue of this publication, insuring uniformity. The author's discussion on the normalizing of steel contains impressive information. One mine, for instance, reduced its purchases of new steel 90 per cent by the adoption of the process. At another property the total cost of the relatively expensive normalizing equipment was amortized in three months by the reduction effected in amount of new steel purchased.

A. Leyland

THE drill shop of Randfontein Estates Gold Mines, on the Witwatersrand, in the Transvaal, handles from 10,000 to 11,000 steels per 8-hr. day. The total weight of steel in use, in transit, and being sharpened is about 170 tons. Of the nineteen sharpening machines in the shops fourteen are used for sharpening, three for making up and repairing, and two are held in reserve. They include the Gardner, Ingersoll-Rand 4 and 5, and the Waugh types.

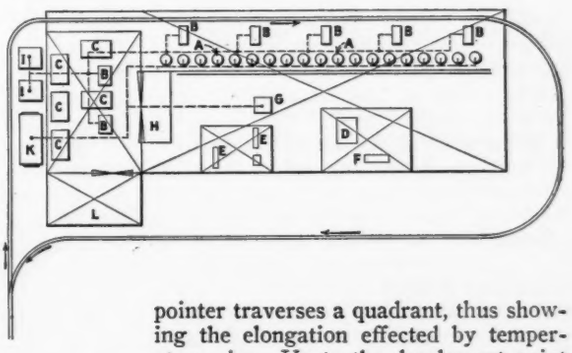
The steel used is 1¼-in. hollow of 3-ft. 6-in., 5-ft., 6-ft. 6-in., and 8-ft. lengths, for cradle drills; ⅞-in. hollow-hexagon steel, of 3-ft. 3-in. and 5-ft. lengths, for jackhammers; 1-in. hollow hexagon steel of 3-ft., 4-ft., and 5-ft. lengths for "pompom" drills. About 160 jackhammers and 24 "pompoms" are in use.

Each four of the nineteen drill-sharpening machines is supplied with an oil-fired furnace capable of heating about 16 steels at once on each side of the furnace, or a total of 32. The machines and furnaces are placed in one section of the shop, as indicated in the accompanying plan, a track running through the shop and out again to enable the trucks loaded with drill steel to be brought into the shop at each shift, and, when the steel has been sharpened and sorted, to be run out again on the return track to the various shafts.

Bent drill steel is straightened by an air-operated hammer. Welding of steel is done in a butt-welding machine. The steel is ground on the ends, then electrically welded in the ordinary manner. The shanks are turned up to standard gage in two turret lathes.

At this property all steel is tempered in a bath, kept at a temperature of 800 deg. C., containing two parts of potassium chloride to one part of barium chloride. Five baths are in use, each of which handles about 2,000 bits per shift. The consumption of salts is about 8 lb. per shift.

To secure uniformity in temper throughout, the following procedure has been employed: Part of the drill shop is divided to form a tempering room, which is kept dark. Each bit is heated in an oil-fired furnace to a temperature of 770 deg. C. A special matching color device is employed, described in a recent issue of this publication, the liquid in which simulates red-hot steel.



***A*, Sharpening machines; *B*, Oil furnaces; *C*, Tempering baths; *D*, Butt welder; *E*, Turret lathes; *F*, Grindstones; *G*, Air-operated hammer; *H*, Sorting table; *I*, Oil-supply tanks; *K*, Air receiver; *L*, Dispatch bay.**

In regard to the normalizing of steel opinion differs, but one mine on the Rand has reduced its purchases of new steel by about 90 per cent since the process was adopted, and breakage of steel has been reduced to about 15 per cent of what it previously was. At the Randfontein Gold Mines all drill steel is normalized about once per month, after about eight or ten resharpenings. The cost of the normalizing plant is heavy; but in this instance, after allowing for working costs in labor and current, the capital outlay on the plant was redeemed in three months by reduction in cost of steel purchased.

In normalizing, the steel is raised to its decalescent point—from 1,300 to 1,400 deg. F. The heat added in this manner acts to change the structure, and enables the fibers to reset themselves into their original form. A somewhat similar condition occurs as the temperature falls, the temperature ceasing to fall for a time although heat is removed from the metal. This point in the falling temperature, called the recalescent point, is usually about 50 deg. F. below the decalescent point. These two points are of considerable importance, because the quenching of the bits should be done, if possible, between these two temperatures and in any event at not much above the one or below the other. Another advantage of normalizing is that cracks in the length of the steel are shown up. The crack reduces the conducting area for the current so that, in the immediate neighborhood of a crack, the temperature rises to a greater extent than in the non-flawed body of the steel, thus enabling it to be repaired at the flaw before it has actually broken.

The steels are clamped in heavy copper terminals, one pair of clamps as near as possible to each end of the bit. One of the clamps is movable endwise to accommodate different lengths of bit. Current is applied through the clamp, and the length between the clamps is quickly raised to a bright-red heat. A pointer is connected to the movable clamp, and as the bit temperature rises, and the clamp moves endwise, the pointer traverses a quadrant, thus showing the elongation effected by temperature rise. Up to the decalescent point the pointer moves at a fairly uniform rate, but when that point is reached, it ceases to move forward and sometimes moves slightly backward, though the current passes through the bit at the same rate as before. If application of heat be continued, the pointer again will begin to move. Should the bit be left in the clamp after the current is cut off, the recalescent point is indicated by a stoppage of backward movement of the pointer.

In normalizing, the current is cut off as soon as the pointer begins to move forward after the decalescent point has been reached. The steel is then removed

from the clamps and allowed to cool in the air. For 1-in. hexagon steel a current of 12,000 amp. is used, the voltage, which naturally varies with the length of bit, being about 10. To carry 12,000 amp., about 12 sq.in. of copper conductor is needed between the transformer secondary and the normalizer clamp. To attain this section and to enable the clamps to move freely, several flexible copper bands are employed. The secondary windings of the transformer also must be of large sectional area. To provide for this the secondary winding has several conductors in parallel. The necessary variation in the secondary voltage is attained by means of a series of tappings on the primary windings, a switch being provided for giving the desired range of adjustment.

After the normalizing treatment, the steel is collected in a light trolley and passed to a sorting table. Each piece is separated and passed through to the tempering room. After tempering, the drills go to the distributing station, where they are loaded on drill trolleys and transported to the respective shafts.

■ ■ ■

Automatic Circulation of Plant Water

J. B. Huttl

Assistant Editor

ATTAINMENT of reliable and economic pumping service depends to a large extent on the selection of appropriate equipment, in union with a well-designed plant layout. One of the best examples, illustrating the success accomplished by the use of modern pumping equipment and the application of all-automatic pump control, is the new secondary pump station installed recently at the concentrator of the Nevada Consolidated Copper Company at Hayden, Ariz. Water for mill operations is obtained from an air-lift water system, about one mile from the plant, consisting of a series of shallow wells, with air-lift pump installations, which discharge the water into a common reservoir, conveniently situated near the primary pump station, whence it is pumped against an average head of 195 ft. by three motor-driven 16x18-in. vertical quintuplex plunger pumps, with a rated capacity of 3,300 g.p.m. each, to the 50,000-gal. capacity concrete suction tank of the secondary pumping plant. From here the water is pumped direct to the mill reservoir. Part of the water pumped is taken at strategic points from the primary pump discharge column and used for other purposes at the plant. All pumping equipment at the primary pump station is hand controlled.

The new secondary pump station, a general arrangement of which is shown in Fig. 1, consists of two 12x10-in. Type SH Allis-Chalmers centrifugal pumps, each direct-connected to a 125-hp. Allis-Chalmers synchronous motor, running at 900 r.p.m. Power is obtained at 440 volts. The pumps are duplicates, except that one pump is assembled for clockwise rotation and the other for counter-clockwise rotation. Owing to a slight difference in the diameter of the impellers, the capacity of the pumps is 3,000 g.p.m. and 3,600 g.p.m., respectively, when pumping against a maximum head of 102 ft. Excitation is furnished by a small motor generator set.

Each pump is provided with the following automatic control equipment, supplied by Barrett, Haentjens & Company: An automatic priming valve; a priming chamber, with a float-operated double-pole switch; a single-pole pressure relay, on the discharge side of the pump, which closes at 34-lb. pressure and opens at 30-lb. pressure; a 12-in. check valve equipped with a double-pole switch. This switch remains closed when the check is open, and opens when the check closes. Fig. 2 illustrates the neat and compact float switch installation at the suction tank. The floats and counterweights operate in a series of steel pipes welded to a common base and bolted to a traversing channel iron by six $\frac{3}{4}$-in. U-bolts. Two of the float switches control the starting and stopping of the pumps, the third being used to operate an overflow signal. The pump motors are controlled by full-voltage starters, and the exciter set is governed by an across-the-line starter. All master and timing relays, the exciter control, exciter rheostat, and instruments are mounted on a panel adjacent to the two pump motor starter panels. Motor starters, float switches, and timing relays were manufactured by the General Electric Company, and the master relays and the exciter starter are Westinghouse equipment. The Penn. Electric Switch Company furnished the pressure relays.

The two pumps are installed with their center line 8 ft. below the spillway of the suction tank, which provides a moderate head on the pump suction. Both priming chambers are mounted at a point calculated to close the control switches on the 3,000 g.p.m. and 3,600 g.p.m. pumps when the water level is 2 ft. and 3 ft. 6 in., respectively, below the spillway of the suction reservoir. The float switches are adjusted to close at a water level 6 in. and 12 in. below the spillway. These measurements are also applied in adjusting the pumping range, which avoids a simultaneous shutting down of the pumps. The pump that comes into operation last is the first one to shut down.

In Fig. 3 the wiring diagram illustrates the sequence of operations of the automatic control equipment. As pumping operations proceed at the primary pump station, the water rises gradually in the suction tank of the secondary pumping plant and flows through the pump casings to the open priming

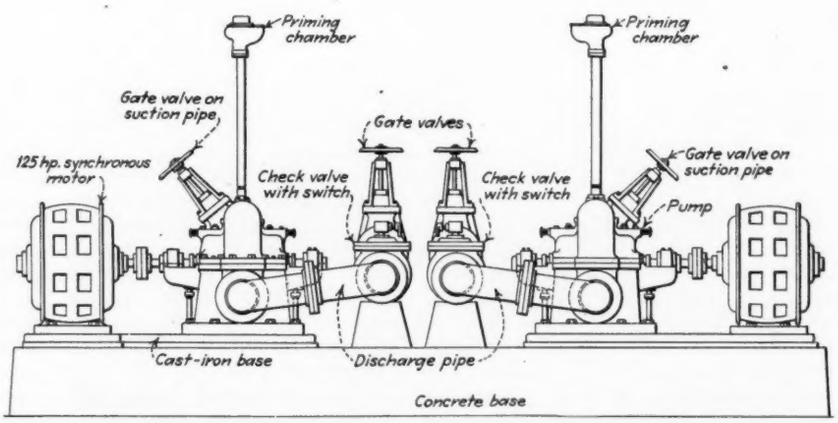


Fig. 1—General arrangement of secondary pump station

valves. When the water has reached the levels below the spillway, the floats in the priming chambers are slowly raised, thereby closing the priming switch contacts APS_1 and APS_2 on pump A, and BPS_1 and BPS_2 on pump B. At a water level of about 12 in. below the spillway the float switch AFS_1 closes, and thus energizes the timing relay $AMa = AMo$ and the master relay AR, which contains three normally open and one normally closed contacts. After relay AR is energized, contacts AR_1, AR_2, and AR_4 close, and contact AR_3 opens. Closing of contact AR_2 starts the motor-generator set by energizing MG, which closes contacts MG_1, MG_2, and MG_3. The field rheostat of the exciter is shunted by contacts AX_2 and BX_2, as well as contacts $AFDS_2$ and $BFDS_2$, which are in parallel. AX and BX are excitation relays, each with one contact normally closed and one normally open. $AFDS$ and $BFDS$ represent three-pole disconnecting switches, two poles of which are used to disconnect the excitation supply to the motors, the third pole being in the rheostat shunting circuit.

Relays AX and BX are adjusted to

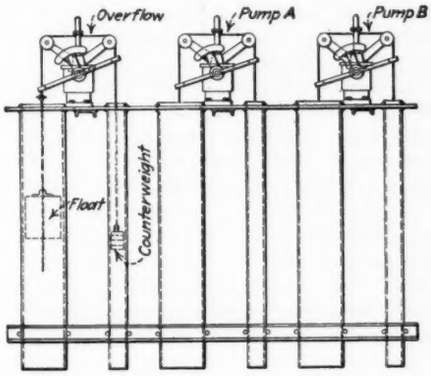


Fig. 2—Float switch installation

pick up at 80 volts, and, with the rheostat shunted out, the exciter voltage rises rapidly to that voltage, closing contacts AX_1 and BX_1, and opening contacts AX_2 and BX_2. The closing of AX_1 completes the starting circuit, ALE closing contacts ALE *1, 2,* and *3,* and starting the motor through the regular sequence of the starter. About 3½ sec. is required for the motor to attain full speed. The moment the pump is operated at normal speed, the prevailing pressure closes the automatic priming valve, and the pressure relay contacts APR_1 while the flow of the water opens the check valve and closes contacts ACV_1 and ACV_2. The circuit through AR is now completed by ACV_1 and APR_1. Closing of the priming valve, and consequent loss of head, effect a slow draining of the priming chamber connected to the pump suction by a check valve. This action opens priming switch contacts APS_1, holding the pump on the line through ACV_1 and APR_1, and in turn opens contacts APS_2,

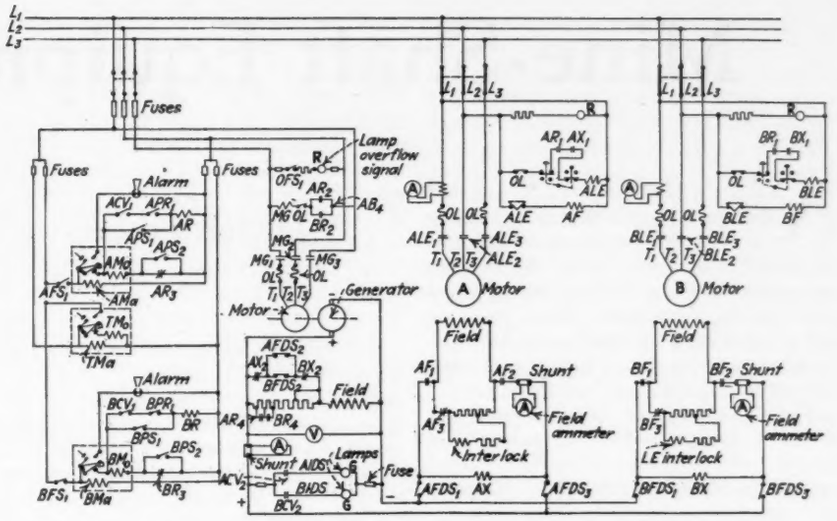


Fig. 3—Wiring diagram of automatic-control equipment

which release the motor circuit AMo of the timing relay. The closing of ACV_2 lights a green signal lamp at the power plant switchboard, and indicates to the operator that the pump is in operation. Contacts AR_4 and BR_4 shunting a portion of the exciter rheostat, cause the proper exciter voltage to be maintained regardless of whether one or two pumps are operating.

When the water level in the suction tank has been lowered to a point where AFS_1 opens, the pump and exciter units stop immediately. The starting of the second pump is similar to the procedure described, except that when one pump is already running, in which instance the exciter set is also in operation, the closing of BFS_1 starts the pump motor without delay. If a pump motor fails to start correctly, or any other mechanical trouble develops, the timing relay locks out and shuts down the unit at once, simultaneously sounding an alarm at the power plant switchboard. In the meantime, the idle second pump will start up as soon as the water level rises to close float switch BFS_1.

The automatic control mechanism protects the plant against the following inconveniences, and in each instance sounds the alarm:

1. Failure of priming chamber to fill, or priming switches to close. This can occur for the following reasons: (*a*) priming float mechanism sticking; (*b*) switch adjustment incorrect; (*c*) pump suction valve closed; (*d*) valve in line from priming valve to pump chamber closed; (*e*) priming line choked.

2. Failure of priming chamber to drain, or priming switches to open, which can be caused by the following: (*a*) priming float mechanism sticking; (*b*) switch adjustment incorrect; (*c*) automatic priming valve failing to close; (*d*) pump discharge valve closed; (*e*) valve in line from priming chamber to pump suction closed; (*f*) priming chamber drain line choked.

3. Failure of master relay to close. This can be caused by: (*a*) coil of relay burned out; (*b*) open circuit in master relay circuit.

4. Broken discharge line, allowing the pressure to drop below 30 lb.

5. Failure of reservoir float switch to open when the water has fallen to the lowest level.

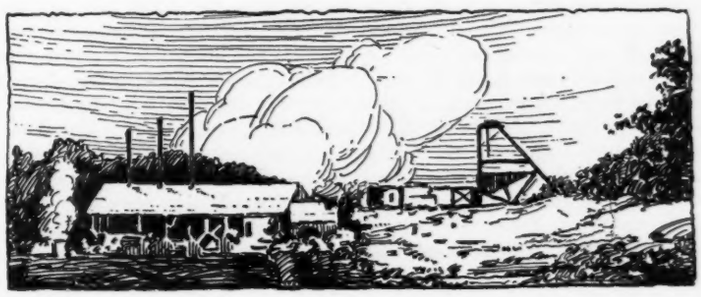
6. Overload on pump motors.

7. Start-and-stop pushbutton left in stop position.

8. Motor a.c. or d.c. disconnecting switches left open.

9. Motor-generator set fails to start.

In conclusion, grateful acknowledgment is made to J. D. Sullivan, electrical engineer, for his assistance in compiling and arranging the data here presented.



Mine-Shaft Equipment—II

Lucien Eaton

A PREVIOUS ARTICLE covered preliminary considerations essential to the proper location and efficient design of mine shafts, the relative advantage of the circular shaft as compared to the rectangular shaft, the size and arrangement of shaft compartments. Treatment of the subject continues with a description of skip compartments:

The size of the skip compartments depends on the size of the skip, and that in turn on the hoisting capacity required or on the lifting power of the hoist, if this is already on hand. In vertical shafts, 3 in. clearance is left between the shaft timber and the front and back of the skip, and 3 in. or more from the face of each guide to the side of the skip box. This determines the maximum cross-section of the box of the skip, and the height should not be greater than three times the thickness from front to back; two times is better. To prevent spill in loading or blocking of the loading chutes, the skip should not be too narrow; 10 per cent extra volumetric capacity over and above normal load should be provided.

Fig. 1 to Fig. 7, inclusive, will be found among the illustrations in the previous article, which see. In Fig. 3 the skip compartments are 4 ft. 3 in. x 5 ft. 1 in. They were designed for 4-ton skips, but 5-ton skips are successfully used in them. In Fig. 5 the skip compartments, each 5 ft. 1 in. x 5 ft. 6 in., are designed for 7-ton skips. In Fig. 4 and Fig. 6 the skip compartments are 6 ft. x 5 ft. 9 in., and are designed for 10-ton skips. In Fig. 1, an inclined shaft, the skip compartments are 4 ft. 1 in. wide by 5 ft. 9 in. high, and the average capacity of the skip is 7,100 lb., a little over 3½ tons.

A comparison of several vertical shafts in operation in various parts of the world gives the following capacities in tons for skip compartments of the areas stated: 2 tons, 16 sq.ft.; 3 tons, 21 sq.ft.; 4 tons, 22 sq.ft.; 5 tons, 26 sq.ft.; 7 tons, 28 sq.ft.; 9 tons, 31 sq.ft.; 10 tons, 34½ sq.ft. Skips of similar capacity for inclined shafts require compartments 20 to 25 per cent larger, depending on the design of the skip.

The cage compartment shown in Fig. 3 is 6 ft. wide and 10 ft. 10 in. long. A single-decked cage in this compartment carries 28 men comfortably, and is large enough for a 6½-ton locomotive, or a 65-cu.ft. gable-bottomed car, if the couplers are removed; timber trucks loaded with poles 9½ ft. long are easily handled. The cage compartment shown in Fig. 4, 8 ft. wide and 12 ft. 6 in. long, will handle an 8-ton locomotive or a 92-cu.ft. Granby car, and can carry 50 men on each deck.

Where small cages are used, the cage compartments are usually of the same size as the skip compartments, so that skips and cages may be interchangeable. At small mines, where the ore is hoisted on cages, the cage must be large enough to handle the tramcars, and the sizes of the cages now used in many districts were originally determined by the dimensions of the one-ton cars used. A common size is 4 ft. 6 in., or 4 ft. 8 in. wide, on line with the guides, by 5 ft. between wall plates. On the Rand, similar compartments vary from 5 ft. x 5 ft. 6 in. to 5 ft. 6 in. x 6 ft. 6 in.

The use of a skip in one compartment in balance with a cage in another compartment is not to be recommended.

Other compartments in the shaft are used for: (1) Pipes; (2) ladders; (3) counterweight; (4) ventilation. Pipes and ladders are frequently in the same compartment, as shown in Figs. 1, 2, and 3, or they may be in separate compartments, as shown in Figs. 4 and 5.

The size of the pipe compartment depends on the size and the number of pipes and cables required. A large, wet mine, having two or more water columns, two air pipes, a siphon pipe, water pipe, and various signal and power cables, may require a large compartment, as in Fig. 6. The compartment must be large enough to allow room for working on the pipes, and for bearers for the water columns.

The ladderway should be at least 3 ft. wide. That shown in Fig. 5 is only 2 ft. 7 in. wide at the sets; but between sets the actual width is 3 ft., so that room is provided to pass around the ladder at the sollar. In Fig. 3 the ladderway is 3 ft. 6 in. wide, but there are pipes also in this compartment, and no waste space. Normally one of these shafts has in this compartment, in addition to the ladders, one 8-in. flanged water column, one 12-in. flanged counterweight pipe, one 6-in. flanged air pipe, one 3-in. siphon pipe, and two 1-in. pipes for water for the drills and air for the fire doors. Cables are as follows: Two for the pumps, one for the scraper hoists, one for electric haulage, one for lights at the stations, one for telephone, and one for signal bells.

An advantage in having the pipes and cables in the same compartment with the ladders is that they are easily accessible for inspection and repair. Another advantage is that the room required for passing around the ladders serves also partly as working space for the pipes and cables, and reduces the amount of dead space in the shaft. To keep steam pipes out of the ladderway, however, is good practice.

When only one cage is employed, it is usually balanced by a counterweight, which may run on guides, as shown in Fig. 4 and Fig. 6, or inside a pipe. For a counterweight up to 5 tons in weight, the latter arrangement is satisfactory. Counterweights running on guides give little trouble, however, and may be fitted in wherever convenient. They take up more room than those running in pipes, but have advantages, which will be discussed later. Clearance for counterweights is not as large as is required for skips and cages, and may be safely reduced to 2 in.

Occasionally one compartment may be reserved for ventilation, in which event it should be smoothly lined. Size is determined by the volume of air to be passed through. Under normal conditions, however, the ventilating current passes through the other compartments.

The question of shaft lining and timbering has received more attention of late, and important changes in practice have been made during the last fifteen years, partly because of the higher cost of timber suitable for shaft sets, and partly by the desire to reduce fire hazard and to secure permanence. Most of the shafts sunk in recent years have been lined with steel or concrete, or both.

In some districts and in some rock formations, notably in the flat-lying limestones of the Southeast Missouri lead district, and the Tri-State zinc district, to sink shafts without any support for the walls is customary, and, if hoisting is done with buckets, or "cans," the only timber required is near the collar. If skips and cages are used, the only timbers are the dividers that carry the guides, and these are set in hitches cut in the walls. This practice, followed in a few other places, is comparatively rare.

Timber has been the material almost universally used for lining shafts. In its usual form it is framed in sets, held apart by posts, or studdles, and the ground between sets is supported by lagging. Examples of wooden sets of different sizes and types are shown in Figs. 1, 2, and 3. Fig. 2 illustrates a typical layout for a medium-sized shaft, and the relationship of the different members. The end plates and wall plates are usually framed as shown, in order to resist pressure from the ends as well as the sides. In Fig. 1 the framing is different, and is designed to resist side pressure only.

The posts, or studdles, between the sets are placed at the corners; in long shafts, at the ends of the dividers also. Their length varies, but is commonly about 4 or 5 ft., sets being placed on 5- or 6-ft. centers. Distances over 6 ft. between centers make the span too great for ordinary lagging or for wooden guides, although steel guides are successfully used, having unsupported spans of 10 ft.

Shafts are occasionally cribbed with sets only 3 in. apart, or even "skin to skin." This may be necessary in heavy ground, and it may be economical in strong ground, if a good deal of coarse, abrasive ore falls down the shaft when the skips are loaded or dumped. In such case, inside as well as outside lagging would be required. The difference in the amount of timber used in cribbing and in putting in separate sets with double lagging is not great, and less labor is involved in laying up the cribbing.

Lagging is usually of 2-in. or 3-in. plank, the thickness chosen depending on the distance between sets and the pressure to be resisted. Occasionally, round or split lagging is employed, but it is not recommended. To block behind the lagging with wood is best, using bridging if necessary, and not to fill with waste rock, which can safely be used behind cribbing, however. The lagging is placed outside the sets, and is held by a 2x2-in. strip nailed to the back of each wall plate and end plate, as shown in Fig. 2.

The size of the timber used varies in different parts of the world, and is apparently partly a matter of guesswork. The correct size required is determined by experience, and "it is better to be safe than sorry." Consequently, the error has usually been on the safe side, and the largest size that can be conveniently handled and purchased is used. In the northwest of England, many shafts are cribbed with 4-in. pine, and have stood for many years. On the Rand, in South Africa, the standard size for shaft sets is 9 in. square with 3x9 in. lagging; and in parts of the Western United States, 8x8-in. and 10x10-in. timbers are commonly used, with 2-in. plank for lagging. In the Lake Superior iron country, 12x12-in. timber with 3-in. lagging formerly was standard, but most of the shafts sunk in recent years have been lined with steel and concrete.

Bearers—the timbers from which the shaft sets are hung—are usually of deeper section than the shaft sets themselves (for 12x12 shaft timber the bearers would be 12x16 or 12x18, or two pieces of 12x12 would be placed one on top of the other). The shaft sets are set in hitches cut in the solid rock beyond the line of excavation. They are wedged in place. Filling of the space around the ends of the bearer with concrete is good practice. Bearers are commonly placed across the ends of the shaft under the end plates, as this is the shortest span; additional bearers are sometimes placed under the dividers.

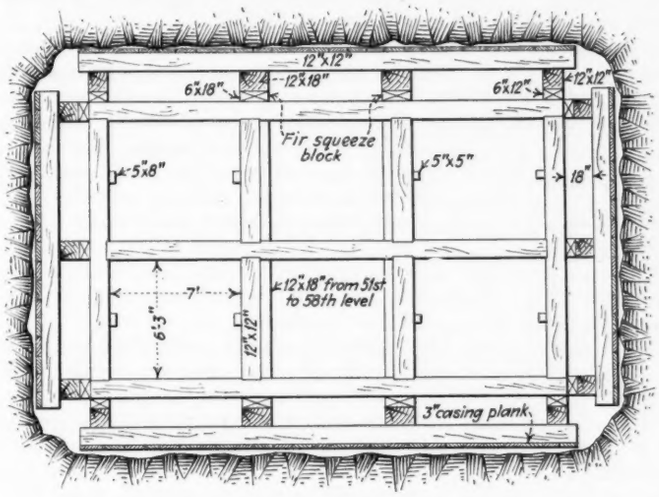


Fig. 8 — Umbrella timbering, Red Jacket shaft, Calumet & Hecla Cons. Copper Company (I.C 6526, U. S. Bureau of Mines)

The sets are hung from the bearers by hanger bolts, made of round, soft steel, ¾ to 1¼ in. diameter, 1-in. being almost standard size. One end is turned over in the shape of a hook, and the other is threaded and fitted with a heavy washer and nut. Bolts are usually in the end plates, as these pieces are more easily handled than the wall plates; and there are eight bolts for each set, four up and four down. The hooked ends facilitate hanging the new end plate from the one above, and are more convenient and more easily formed than eyes.

Bearers are ordinarily put in at intervals of 60 to 120 ft., usually about every twenty sets. Although the sets as put in place are hung from the bearers above, after a while they settle a little on the studdles, so that the weight is carried on the bearers below. With steel sets this is not usually so, the steel studdles being always in tension. This difference should be borne in mind when designing and putting in steel sets.

To find any lining that will resist the pressure that develops in ground that is moving is difficult; and under such conditions the best solution of the problem has been to use double sets of timber, one outside the other, with space between, which have been named "umbrella sets." An example of this method of timbering is shown in Fig. 8, which represents the timber in the Red Jacket shaft of the Calumet & Hecla Consolidated Copper, where it passes through the lode at a depth of over 3,000 ft. By this construction, when the outer set is deformed, the shape and position of the inner sets can be maintained with a minimum of delay in hoisting by changing the blocking between the inner and outer sets. When the outer set is too badly crushed, it is removed, more room is excavated, and a new set is put in. Wood is the only material that can be used successfully in this way.

The advantages of timber for shaft lining are: (1) It is usually the cheapest and most convenient material to use; (2) it is easily framed and placed; (3) it is not eaten or corroded by acid waters; (4) it gives warning before it fails; (5) when broken by pressure or accident, it can be chopped out and replaced with a minimum of difficulty or loss of time. Its chief disadvantages are: (1) Its bulk, for it takes up more room than steel; (2) the danger of fire; (3) its comparatively short life, when it is not always wet; dry timber rots quickly in some climates, and it is subject to the attack of insects, especially in the tropics, but its life can be materially increased by treatment with a chemical preservative.

In an upcast shaft the fire hazard is not so important as in a downcast shaft, because the smoke and fumes from a fire in the shaft would be carried out of the mine and not into it. For this reason downcast shafts should be fireproof, or at least fire-resisting.

If the expected life of a shaft is greater than that of the timber with which it is lined, so that re-timbering will be necessary, the use of some other kind of lining, which will not have to be replaced, is usually more economical. The fire hazard will also be reduced.

The life of untreated timber in a dry shaft is about ten years, if Douglas fir or pine is used; but local conditions may lengthen or shorten this period. Timber that is always wet lasts indefinitely. I have seen shaft timber that had been in place for 60 years and was still sound. Treatment with a preservative, such as zinc chloride, will double or treble the life of dry timber.

Steel shaft sets have become common in recent years. The usual sections used are H-beams or columns, but I-beams, reinforced with angle irons, possess advantages that should not be overlooked. Two examples of modern, steel-lined shafts are shown in Figs. 4 and 5.

The sets shown in Fig. 4 are made of 6x5 in. I-beams, weighing 25 lb. per foot, and the members are fastened together with angles and bolts, using lock washers. Studdles are at the corners only, and consist of 6x6x½-in. angles. Corners of the wall plates and end

plates are beveled, and rest upon a bracket one foot above the lower end of the studdle. The shaft is lagged with 2-in. plank, held in place against the outside flange of the steel by means of a beveled strip of wood, which in turn rests against the inside flange. Holes are drilled in the sets to drain off the water that might otherwise accumulate. At this shaft the ladder sollars are made of 3-in. plank; but the ladders are steel; and heavy, corrugated, galvanized sheets are used as casing between compartments. Sets are on 6-ft. centers.

In Fig. 5 the sets are made of 6x6 in. H-beams, weighing 23.8 lb. per foot, which are reinforced by two 2½x2x¼ in. angles, riveted to the web so as to make a slot for holding the lagging, of reinforced concrete in the form of slabs 2½ in. thick. Studdles are 3½x2½x½ in. angles, and fourteen are used for each set. The ends of the wall plates and end plates are not beveled, and the members are bolted together by means of short angle irons of the same size as the studdles. These short angles extend 7½ in. above and below the sets, and to them the studdles are bolted. Sets are on 6-ft. centers. The ladder-road is inclosed with thin, reinforced concrete slabs.

In both of the shafts just described the lagging is flush with the outside of the shaft. Making the lagging flush with the inside of the shaft possesses advantages, and is common practice. If this is done, however, the lagging must be held in place by angle irons riveted to the sets, as used in the shaft shown in Fig. 5. Flush lagging prevents the accumulation of ore on the sets and the increase in corrosion that such a condition may be expected to cause. Moreover, it permits pouring the concrete behind the lagging between and around the sets, using the lagging as forms. If this is done, lighter steel sections and lighter lagging can be used than would otherwise be required. This concrete may be continuous, or it may be poured in alternate sets only, forming rings. Such rings may be used instead of bearers, for which they serve as an excellent replacement.

If the construction shown in Fig. 4 is used, bearers cannot be placed directly under the end plates, because the studdles are in the way. They are therefore attached to the outside of the studdles by means of a special bracket, as shown. These bearers are usually 10- or 12-in. I-beams, set in concrete in hitches cut in the walls.

If the water in the shaft is decidedly acid, to use steel is not advisable; but, if it is alkaline or only slightly acid, steel sets are satisfactory if dipped in acid-resisting asphalt paint after fabrication. The use of copper-bearing steel increases resistance to corrosion, and its use is to be recommended whenever the danger of corrosion is serious. In the Lake Superior iron country the water in the footwall, where most of the shafts are sunk, is often acid, but the water in the orebody is alkaline, and little if any trouble has been experienced from corrosion.

The advantages of steel as a material for shaft sets are as follows: (1) It takes less room than wood; (2) it is strong, and bends more often than it breaks; when bent it can often be straightened on surface, and be used over again; (3) it is easily placed; (4) it is fireproof; (5) it does not rot and is not subject to the attack of insects. Its disadvantages are: (1) It often costs more than wood; (2) when wrecked through accident or excessive pressure, it cannot be chopped out, and it cannot be cut to fit underground; (3) it is corroded by acid water.

Use of concrete as a lining for shafts has increased rapidly. Although its advantages were appreciated at a comparatively early date, use was limited, on account of high first cost and certain difficulties in handling and placing, which caused delays in sinking; but the higher cost of timber and the lower cost of cement have almost counterbalanced the first objection, and the improvements made by manufacturers of concrete-mixing and placing machinery, and the ingenuity in its application and use displayed by engineers, have overcome the second objection. A great impetus to the use of concrete for lining shafts was given by the occurrence of several disastrous shaft fires, which caused a deplorable loss of life.

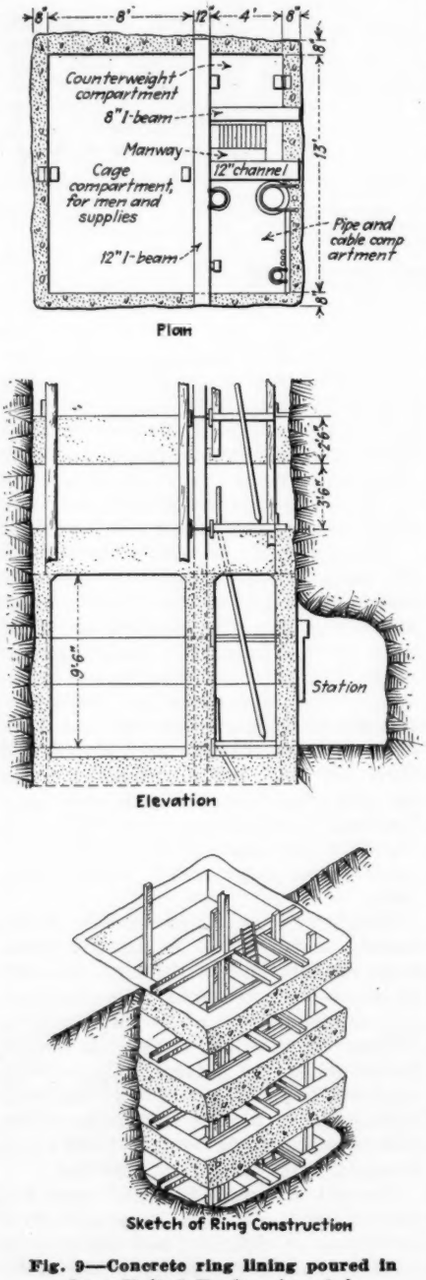


Fig. 9—Concrete ring lining poured in place, United Verde mine, Ariz.

Concrete is fireproof. It is strong, and its strength increases with age. It does not rot, nor is it corroded or easily disintegrated by acid water, although this does sometimes occur. And, if applied so as to cover the whole rock surface, it stops air slacking and the pressure and rock failure that usually follow, and seals off flows of water under moderate pressure. Its disadvantages are its somewhat higher cost and the difficulties of placing.

Concrete may be poured in place, or it may be pre-cast, and the members so cast may be placed in position later. Each system has its advantages and its advocates. Concrete that is poured in place may be reinforced or not, and probably in the majority of cases it is not. It may be monolithic or continuous, or it may be poured in rings, separated by spaces, in which the ground is unsupported. Pre-cast concrete bricks are not reinforced; but wall plates, end plates, dividers, and slabs for lagging or casing are reinforced. The reinforcing in the beams consists of rods or deformed bars ¼- to ⅝-in. diameter, and in the slabs of small rods, wire mesh, or expanded metal.

In pouring concrete in place, removable steel forms that may be re-used are usually employed. These find their best application in circular shafts sunk in ground that will stand unsupported for considerable distances. The best examples of such practice are probably on the Rand, in South Africa, where shafts have been sunk 200 to 400 ft. below the lining. This full height was then concreted, enough forms being provided to cover the whole distance. If no dividers are to be used in the shaft, as is true when rope guides are used, this method is comparatively simple, but it becomes much more complicated when dividers are used. Sometimes stubs, or short pieces of structural steel, to which the dividers are to be bolted, are set in the concrete wall as it is poured; but their accurate alignment and location is a delicate procedure, and the practice is not to be recommended. A better scheme is to block off "hitches" in the concrete for the ends of the dividers, these "hitches" being large enough to allow inaccuracies of a few inches without causing disalignment of the dividers.

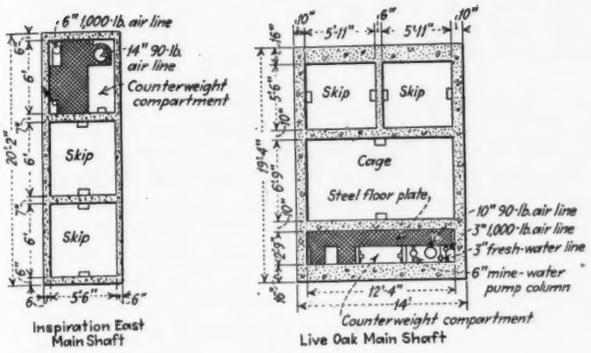


Fig. 10—Monolithic concrete shaft lining

The hitches are later packed with concrete after the dividers have been blocked in place. The fact that the boxes that form the hitches are on the outside of the forms, and cannot be seen until the forms are stripped, prevents an estimation of how accurately they have been placed until after the concrete has set. Concrete dividers are rarely used in circular shafts, steel or wood being preferred. Two good examples of circular shafts lined with monolithic concrete are shown in Fig. 7—the City Deep No. 4 and No. 1 at New Modderfontein.

Rectangular shafts are sometimes lined with monolithic concrete poured in place, and in this form of structure the dividers are likely to be poured at the same time as the walls. Examples of such construction are shown in Figs. 9 and 10.

A simpler process, which combines speed and strength, is to use steel or wood sets with light plank as lagging flush with the inside of the sets, and to pour concrete behind this lagging. The sets are blocked only at the corners, and not behind the lagging, so that the concrete wall is almost continuous. The sets and lagging serve as forms, and the lagging can be removed later, if desired. In this way a shaft may be sunk 1,000 ft. or more, one set only being poured with concrete every 100 ft. or so, to serve as bearers. When the sinking of this section of the shaft is completed, the intermediate sets are concreted in short lifts, starting near the bottom. When using this method, economy sometimes results, in ground that stands well, if alternate sets only are concreted.

The use of pre-cast concrete has definite advantages. It is poured on surface under the best conditions, while sinking is going on, and has time to set and to be tested or inspected before going into service. The same forms can be used over again, and a uniform product should be obtained. The only delay in sinking is the placing and blocking of the sets, and this takes little more time than is required to set the forms for pouring concrete.

Examples of pre-cast concrete sets used in Ecuador are shown in Fig. 11. Those illustrated are especially interesting, and are particularly well adapted to the use for which they were planned—for replacing wood sets with as little interruption to hoisting as possible. In this instance the space behind the sets is filled with waste rock. In addition to the use of concrete in some alternative types of sets, concrete lagging is used as well, making a satisfactory fireproof job.

In circular shafts, notably at Crown Mines, in Johannesburg, pre-cast concrete bricks have been used with success, and have removed most of the objections to which the use of concrete is subject. These blocks are 6 in. high, 12 in. wide, and usually 9 in. deep, and are set in cement mortar. The space behind is filled with waste rock or with concrete, depending on the strength of the walls. At the places where dividers are to be set, the blocks are omitted. All work is done from a Galloway stage, and the dividers and guides are not put in until the shaft has been sunk to its ultimate depth. In these shafts the dividers are heavy steel I-beams, placed at 10-ft. vertical intervals. The methods followed will be described in more detail in a subsequent article.

Stone blocks or burned brick can be used instead of concrete, if necessary. Where cement is expensive, this type of construction may prove to be the most economical. It is suitable, of course, for circular or oval shafts only.

When skips are used, it is good practice to case off the skip compartments tightly from the adjoining compartments, so that spill from the skips cannot fall upon the cage or ladders and injure anyone who may be riding or climbing in those compartments. The ladder road should also be separated from the cage compartment by casing or guards of some sort, so that a man climbing on the ladders cannot get any part of his body in the way of the cage; but this casing need not be as substantial or as tight as that used for the skip roads.

In the shaft shown in Fig. 2 the casing is of 1½-in. plank; in that shown in Fig. 3, although not shown on the drawing, 2-in. plank was used. Corrugated-iron sheets, expanded metal, or wire mesh may be used instead of plank, as shown in Figs. 4 and 5.

Ladders may be made entirely of wood, entirely of steel, or with wooden sides and iron rungs. In dry shafts, iron rungs of ¾-in. round iron are satisfactory; but in wet shafts, turned wooden rungs, usually of elm, 16 in. long, 1¾ in. diameter in the middle, and turned to 1¼ in. at the ends are more comfortable for the hands and are not so slippery as iron. Rungs made of 1x2 in. wood, nailed in notches sawed in the sides of the ladder, are frequently used, but are inferior to either of the above. Wooden ladder-sides are 2x4 in. or 3x4 in. in cross-section, of clear stock free from knots, or may be sawed from straight larch or spruce poles, 3½ to 4 in. in diameter at the small end. For steel ladder-sides, soft steel, 2½x⅜-in. cross-section, is satisfactory.

Ladders should be not less than 10 in. wide between the sides, and rungs are preferably 12 in. apart on centers. If they are more than 12 in. apart, they cause excessive fatigue in climbing; if less, they make too many steps necessary. Ladders should rest on sollars of plank 20 to 25 ft. apart, should slope not less than 10 deg. from the vertical, and should be staggered, so that a man cannot fall further than from one sollar to the next. The manholes in the sollars should be covered by trap doors at shaft stations, unless a gate is provided.

Wooden guides for skips and cages are almost universally used in the United States. Safety catches have been improved until they are very effective on these guides. In Europe and in South Africa, however, not much reliance is placed on safety catches, and in some places a higher factor of safety for the hoisting rope is used and the catches are omitted. Steel guides rolled in a special shape, as shown in Fig. 6, are used at Kimberley and in some of the Rand mines; and, in many places, steel rails, weighing 40 to 80 lb. per yard, are used as guides for cages.

The rolled-steel guides are designed to give an effective section of 4x6 in., but the rails present a much smaller wearing surface. Fish plates are, of course, on the bottom, out of line of travel.

When rails are used, it is common practice to have two rails on one side of the cage only, and this arrangement works very well. I know of no instance,

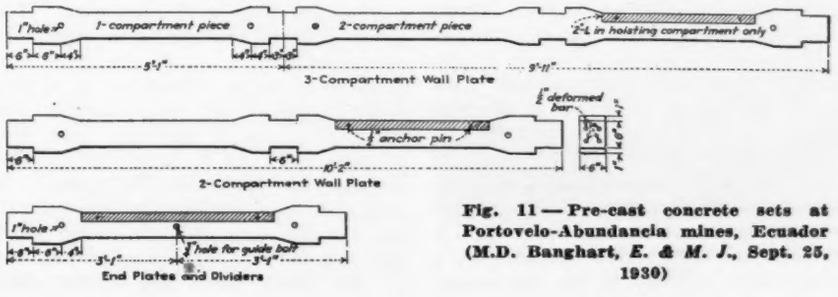


Fig. 11—Pre-cast concrete sets at Portovelo-Abundancia mines, Ecuador (M.D. Banghart, *E. & M. J.*, Sept. 25, 1930)

however, where this idea has been used with skips, but I cannot see why it could not be so used, if the guides were on the back of the bail opposite the dump. Such an arrangement would eliminate three dividers in a circular shaft.

In the Lake Superior districts, fir or yellow-pine guides, dressed from 6x8 in. to $5\frac{1}{2}$x$7\frac{1}{2}$ in., or $5\frac{3}{4}$x$7\frac{3}{4}$ in., are almost standard; but in other districts they may be as small as 4x6 in. in cross-section. The larger section will stand unsupported for longer spans, and its additional width of face gives the safety catches a better chance to hold.

In some circular concrete shafts, wire ropes are used as guides for the cages, four ropes for each cage, and additional ropes are hung between the cage roads to prevent the cages from colliding as they pass each other. These ropes are hung with tension weights of different sizes, so as to minimize sway. When properly installed they have lives of ten to fifteen years. Examples of rope guides are shown in Fig. 7.

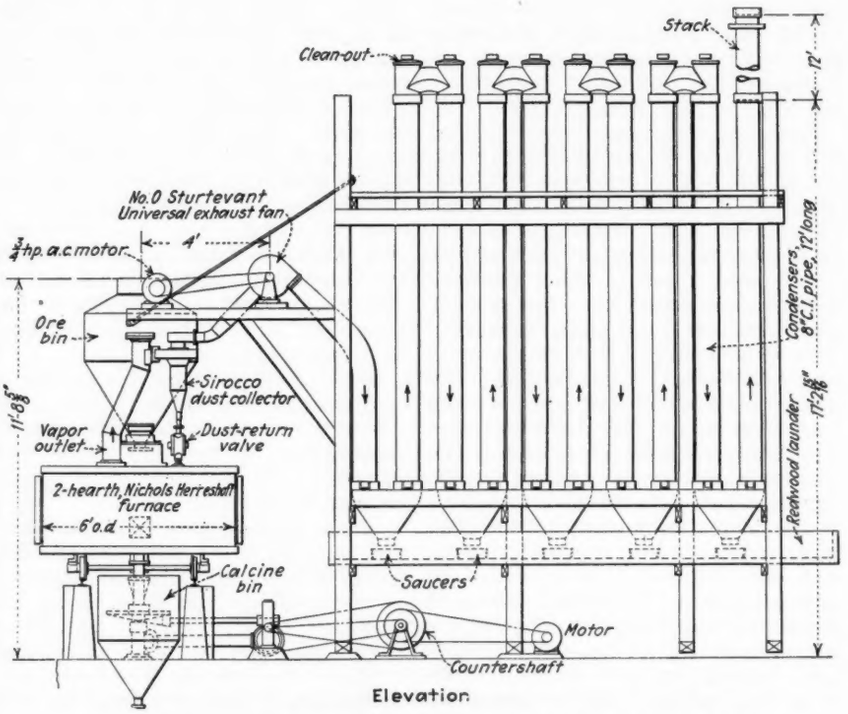
Most of the points to which consideration must be given in planning a shaft have now been discussed. No hard and fast rules can be laid down, because in different places and under different circumstances the weight that must be given to the points discussed varies so widely. Each case must be judged on its own merits, and every advantage possible must be taken of the previous experience of others in the same district.

■ ■ ■

Furnacing Quicksilver Condenser Residues

UNDER CERTAIN CONDITIONS of operation, dust, soot, and entrapped quicksilver accumulate in condenser systems and necessitate further treatment for recovery of the quicksilver. If the amount is too large for treatment by soot tables and simple cleaning apparatus, some special means are necessary for handling this in-between product. Usually a D-retort is pressed into service and the material run through in batches. Much hand labor is involved, and, as a result, costs are high. At the quicksilver property of the Bradley Mining Company, at Opalite, Ore., a split-type Herreshoff furnace and accessories was recently installed for the handling of all dust and soot accumulation from the condenser system of the plant. The new furnace is a two-hearth unit, 6 ft. in outside diameter. The lower hearth has a firebrick firebox, 16-in. inside diameter, into which the Ray oil burner discharges its flame before the flame enters at the lower hearth. Top and bottom of the furnace consist of cast-iron plates. The furnace is split vertically, the movable half being mounted on wheels supported by two tracks, facilitating repairs. A steel hopper bin, the inlet opening closed by a screen and steel-plate cover, stores the dust to be treated. A vapor-tight reciprocating feeder, operated by a cam and lever and the movement of the roaster shaft, delivers the material at a point on the periphery of the upper hearth. At the periphery of the lower hearth the calcine outlet discharges through a pipe into a closed steel hopper bin, from which the calcine is drawn at intervals into a car through a 3-in. blast gate.

The vapor outlet, near the center of the arch of the upper hearth, connects to a small Sirocco dust collector, which returns the dust to the upper hearth through a rotary valve operated by a rocker-arm attached to the mechanical feeder. An exhaust fan removes the vapor and gases from the vertical outlet of the dust collector and delivers them to the condenser, which consists of eight vertical cast-iron pipes, 8 in. diameter by 12 ft. long, connected in pairs at the top by special castings that contain a clean-out plug over each pipe. The lower ends of the condenser pipes are connected by Y's, which discharge into quicksilver trays submerged in a redwood trough filled with water. The outlet pipe, also a condenser pipe, terminates in a 12-ft. stack which discharges the uncondensible gases. A $\frac{3}{4}$-hp. motor is used for the operation of the exhaust fan, and the rabble shaft and the blower supplying cooling air for the rabble arms and central shaft of the Herreshoff are also operated by a similar motor.



Split-type furnace and accessory plant installed by the Bradley Mining Company, at Opalite, Ore.

The day's run of condenser accretion is placed in the feed hopper, the cover luted on, and the furnace started. After adjustment, the unit is almost automatic. The furnace is under a below-atmospheric pressure, and the condenser system is sealed except for the outlet stack. Design and construction are especially good on this point. The capacity of the furnace is estimated to be about a ton per 24 hours. The unit is an important adjunct in a plant where dust and condenser accretions accumulate to more than a nominal degree. It was designed by G. E. Connolly, chief engineer of the Pacific Foundry Company.

PLACER GOLD
In French Equatorial Africa

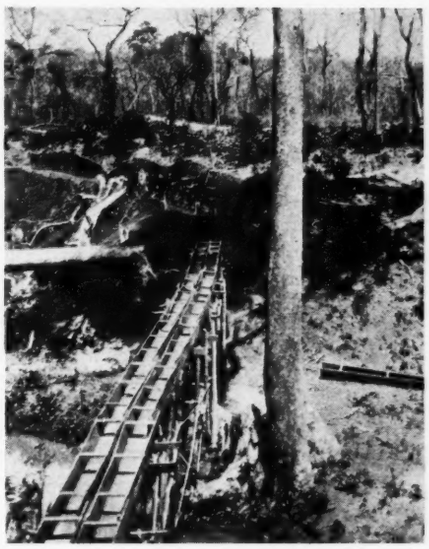
John L. Middleton

DURING April, 1929, placer gold in paying quantities was found in the Baguetta Creek (approximately latitude 6 deg. 5 min. N., longitude 20 deg. 36 min., E. of Paris), in the Oubangui-Chari of French Equatorial Africa. On the twenty-second of the same month I was given charge of prospecting operations of the Compagnie Equatoriale de Mines, in whose concessions the discovery was made, and directed subsequent operations there for the following two years. Since 1929 new discoveries have been made, and, as this company is actually producing gold, the moment of secrecy has apparently passed and something should be known of these deposits.

The region may best be reached by taking any boat from Bordeaux or Marseilles which goes down the West Coast of Africa and lands one at Douala, in the Cameroons; from there one has a day on the railroad to Yaonde, and then five days in an automobile to Roandji, the center of the gold district. The trip from Paris to Roandji should take a bit less than a month. Bambari, the nearest State Post, is 40 miles south of Roandji.

Gold of the Roandji district is found in gravels of creeks that cut the contacts or are near the contacts of a granite batholith which intrudes a sedimentary formation composed of quartzites, schists, and itabirites. The itabirites and quartzites may be traced intermittently for a distance of some 60 miles, owing to their resistance to erosion and the consequent frequency of their outcrops. They form a chain of rugged hills which strikes, in general, northwest by west. Although this direction may be also recorded as the general strike of the sediments, the fact that in some places only cupolas of the granite have been exposed indicates that locally one finds strikes at right angles to this.

Crossing Baidon ferry in the high-water season



Double flume across the Guetoupou Valley

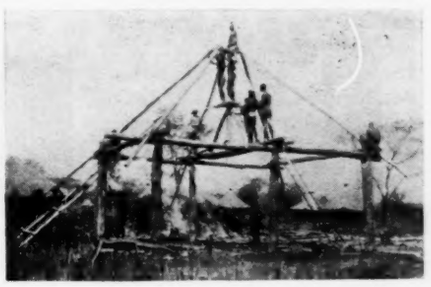
Their dip is always steep near the granite. In some instances, a recurrence of similarly appearing beds of vertically dipping itabirites at approximately equal intervals (about 500 yd.) leads one to believe that they have been pushed into a series of vertical folds, of which only the synclines remain, the tops of the anticlines having been removed by erosion. The itabirites are finely banded rocks of quartz and micaceous specularite. The schists are, for the most part, of quartz, sericite, and chlorite.

That the deposits were formed at great depth is evident by the exceedingly intricate folding in the brittle quartzites and itabirites; the presence of large garnet crystals in some layers of the schists near the contact is equally convincing. In some places quartzite layers containing disseminated pyrite have been found which gave appreciable quantities of gold when assayed. Small stringers of gold-bearing quartz have been found. Small pieces of vein quartz showing visible free gold have been recovered from the gravels in one creek, but so far nothing approaching a paying ledge or vein has been found.

That the granite batholith is responsible for the gold of the region is apparent from a glance at the relations of the placer deposits to the batholith on a map that shows the surface geology. All creeks that cut the granite-sedimentary contact do not yield gold in paying quantities, but at least nine out of ten show higher values at or near the contact. A safe conclusion therefore would seem to be that the mineralization of the rocks at Roandji is to be accounted for by fluids (liquid and gases) forced into the sediments by the granite batholith which intruded them. These fluids, under conditions unfavorable for their migration, mineralized the sediments only near the contact, but, where conditions were more favorable for the migration of the fluids, the sediments were mineralized as far as 1 km. away from the intruding mass. Possibly, in view of the origin of the gold at Roandji, at or near the contact, further development of the region may prove the existence of a ledge or vein carrying sufficient gold to make a hard rock mine, in addition to the placers now being exploited.

The gold occurs in the gravel in particles ranging from the size of dust to nuggets of 64 grams. Although most of it is fine, even the finer particles are spherical in shape, making recovery easy. That chemical as well as mechanical processes have played a part in depositing the gold in the gravels was shown by the finding of a small rotted root with its bark partly replaced with gold in the diggings on the Guetoupou.

The gold is recovered by sluicing, employing methods in common practice in the Belgian Congo. On most of the creeks, wheelbarrows are used in transporting the gravel to the sluices. However, where depth of overburden is little, the men shovel directly into the sluices. Clean-ups are made once a month. The black sands from the sluice are then panned, the gold is recovered, and the sands are stacked for future treatment with mercury. The gold recovered is melted

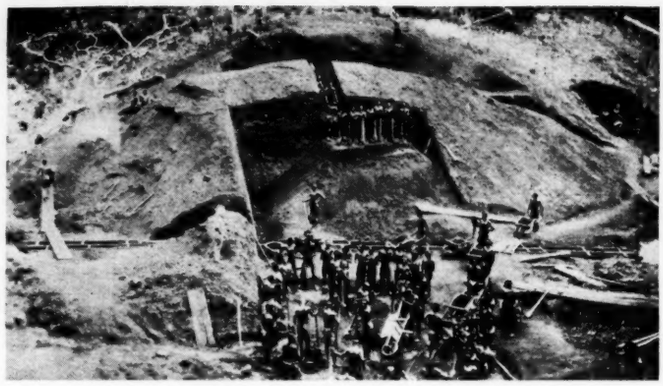


Building a prospector's camp in the Roandji gold fields

and poured into ingots, assaying 96 per cent pure gold, which are shipped to France. Once the preparatory work is done, a crew of twenty men will average about 20 cu.m. of gravel per day as long as the ratio of overburden to gravel is no more than three to one.

Native labor is plentiful, although it is at times unstable. Free medical service is given the natives, and they are taught both sanitation and hygiene.

In conclusion I wish to express my thanks to the Compagnie Equatoriale de Mines for its permission to publish this article.



Constructing an earth dam on Baguetta Creek

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Quarrying Limestone in Arizona

J. B. Huttl
Assistant Editor

ABOUT seven miles north of Miami, Ariz., at Radium, a station on the Arizona Eastern Railroad, the Copper Cities Lime Company is operating a lime quarry and processing plant that are of more than ordinary interest. Several distinct products are produced: lime for the Miami, Inspiration, and Old Dominion concentrators; rock and sand for concrete aggregate; track ballast; and yard chat or gravel. The limestone deposit occurs in a low, rugged mountain range, which forms the southern canyon wall, and is exploited by the conventional quarrying methods. Overburden and limestone from the ledge are broken by drilling a series of vertical holes to an average depth of 14 ft., which are blasted with 60 per cent Apache gelatine dynamite. For drilling, I-R—BCRW 430 Jackhamers and hollow steel are used. Fuse firing is practiced exclusively in blasting the loaded drillholes. Leather belts, attached by safety hooks to manila ropes suspended from the top of the quarry, offer protection against falls to the miners engaged in drilling. The quarry face is over 100 ft. long and 50 ft. high. Broken rock is hand-sorted at the quarry floor. The limestone is hauled by horses in specially designed end-dump carts to the kiln charge floor. Waste, which constitutes nearly 50 per cent of all material broken, is dumped over the stockpiles at the sand and gravel plant. Large boulders are reduced by blockholing, or by hand with sledge hammers if the rock is exceptionally hard.

Construction of the four kilns is the most interesting feature of the plant. These consist of circular raises driven from a tunnel level to the charge floor about 50 ft. above. Each kiln is lined with firebrick and measures 4 ft. in diameter at the top and bottom, and 10 ft. across the belled-out portion in the middle of the kiln. Obviously, with this arrangement, the heat losses through radiation are reduced to a minimum. The capacity of each kiln is about 10 tons a day.

For curing the limestone, the well-known pot method is employed. The 8-in. feed and New Mexico anthracite pea are bedded in precalculated layers at the top of the kiln at the rate the cured lime is drawn off at the bottom of the kiln. Operations on the charge floor resemble blast furnace charging on a small scale. Curing requires about 36 hours. The kilns employ natural draft. Burned lime is drawn at the bottom of each kiln through a concrete chute into standard mine cars, and trammed by hand to six hopper-bottomed steel loading bins. These bins are secured to a superstructure, resting upon a sturdy wooden frame, to facilitate dumping the lime direct into the 5-ton trucks used for delivery. Coal from the storage bin is hoisted over an incline to the charge floor by a small gasoline-driven hoist.

Waste material from the dumps is first crushed in a small Allis-Chalmers jaw crusher, then raised by a bucket elevator and sized in a revolving horizontal steel trommel. Motive power for the trommel, crusher, and a two-drill Ingersoll-Rand compressor is furnished by a 40-hp. Fairbanks-Morse oil engine. Sand is washed in a small plant adjacent to the crushing plant. General repairs are performed in a small shop, in which also drill steels are sharpened and tempered. J. L. Hoopes, manager of the Copper Cities Lime Company, is in charge of operations at the plant.

Center—Quarry of Copper Cities Lime Company, near Miami, Ariz. Left—Incline hoist used for raising coal to charge floor. Right—Limestone is hauled from quarry to kilns in steel end-dump carts.

Geology in the Non-Metallic Mining Industries

Dr. Benjamin L. Miller

THE saying that "the ore is where you find it," with its implication that no one can tell where it is to be found until accident or a blind search reveals it, has long ago been thrown into the discard in most fields of the mineral industry. This is largely due to the advance made in the science of geology during the last half century. With this change of view, the picturesque but inefficient prospector—with his donkey, pick, shovel, pack, and cooking utensils—has all but passed away, never to reappear. Geologists have learned cheaper and surer means for locating the mineral products they seek.

Geology in its earlier development was little concerned with economic applications. It was pursued because it enabled one to exercise his powers of observation and arrive at conclusions that partly satisfied his intellectual curiosity. The practical applications of this information had to come later. All that applied geology with reference to minerals has ever claimed is that it is an economic procedure for the discovery and exploitation of mineral deposits. If expenditure of time, effort, and money were of no concern, no excuse for the economic geologist could fairly be offered. However, progress is made whenever economies are effected. The keener the competition between those producing the same product or between different products, where substitutions are feasible, the greater becomes the necessity for increased efficiency. Here is where geology enters; or, as it has been otherwise expressed, "here is where geology is put to work."

In some quarters geology was once regarded as a mysterious power or method somewhat in the same category as alchemy or the divining rod; but geologists have now largely succeeded in eliminating this false impression. However, this idea is not entirely dead, and one occasionally learns of men who still regard the geologist as a sort of necromancer, whom they watch at work without comprehending the use of the instruments employed or the significance of the observations made.

When one does not comprehend a subject, to doubt its value is easy, or as happened in earlier days, attribute some magic power to the one who can use it to advantage. Many persons, even those in rather responsible positions, are inclined to question or deny the usefulness of any explanation or tool that they do not understand, and that many engineers have been slow to recognize the contribution which geology offers to their profession is therefore not surprising. They are not unique, however, as scientists in general are trained to look with skepticism upon all processes which do not seem capable of scientific explanation, which point of view may be attributed mainly to their own lack of information. Geologists certainly have taken this position. As an illustration, the fact may be cited that many of them were at first inclined to regard some of the geophysical instruments and methods now coming into practical use as belonging in the class of fakes because of their failure at first to appreciate new scientific facts and principles.

Even yet the science of geology is not everywhere regarded as serviceable in comparison with ancient methods and practices. The forked stick and divining rod, in all of their many variations, whether for locating underground water, oil, or other economic materials, are still employed and still credited with unexplainable virtues. Only recently I met a man who claimed to have passed beyond the necessity of employing an instrument of any kind for the location of oil and gas and who boldly stated that he could positively tell whether either of these substances existed in paying quantities in any region without using a modified divining rod with which he started. By holding his hands, palms upward, with fingers bent and the tips lightly touching the palms, he claimed to experience a tingling sensation in the finger tips when passing over gas-bearing sands and pulsations similar to heartthrobs when passing over petroleum-bearing sands. In nearly all rural communities some elderly man is likely to possess a local reputation as a water witch. His services are in frequent demand, and owing to the peculiar predominant mental characteristics of human beings, his successes are recalled and his failures forgotten; hence he continues to practice his art, as he might term it.

Geology in its applications is little more than careful observation and inference based on the data obtained. The conclusions reached are naturally largely dependent on the experience of the investigator or the work of other geologists. Exact and final geological deductions are not always possible, because of the difficulty in evaluating numerous variable factors that enter into many geological problems, and geologists do not always agree. With fewer facts at hand than are needed for a positive conclusion, incorrect explanations or tentative theories are naturally formulated. However, with hundreds of geologists working in practically all parts of the world, continually making new observations, geologic conceptions are constantly sharpened, revised, and improved. Even William Jennings Bryan several years ago was impelled to search diligently the geological archives, to obtain illustrations at which to thrust his swords of sarcasm and wit. In practically every instance his ridicule was directed against long-abandoned and generally never widely accepted theories.

In the metallic mineral industry, the services of the geologist have been employed rather consistently since Becker demonstrated to the miners in Leadville in 1886 that geological investigations enabled them to locate and extract their ores more economically. Since that time it has not been necessary for geologists to justify their employment in the great copper, iron, gold, and silver districts, but, instead, their services have been eagerly sought and their assistance has been appreciated. The insistent demand by mining men for the United States Geological Survey publications on the various metallic districts of the country is evidence of the value of the work done by the Federal geologists.

In the field of the non-metallics, geology has most fully demonstrated its usefulness during the past twenty years in locating favorable areas in which to conduct drilling operations for the discovery of petroleum and natural gas. So

much has been written on this subject that to discuss this application here is not necessary, nor could such consideration be examined adequately within the scope of this article. Suffice it to say that probably there are few oil or gas companies of any importance anywhere that do not employ geologists to direct exploratory investigations. In recent years more geologists have been engaged in the oil industry alone than in all the other branches of applied geology combined, and to a rather large degree the present overproduction of oil can be attributed to their efficiency.

In the coal industry geology has received relatively little attention except in a few localities. Coal mines were opened and operated long before geology had proved its usefulness, and not much opportunity has been afforded to demonstrate the value of geological investigations. Where the coal beds are flat-lying or nearly so, and continuous over large areas, the ordinary miner experiences little difficulty. Even then, however, to understand the conditions under which coal is formed is frequently of great importance. Illustrations might be given of the encountering of horsebacks, partings, splits, and variations in thickness and in quality of coal that have not been understood. A proper appreciation of these and other irregularities of formation is certainly useful. In regions where the coal beds have been greatly disturbed by complex folding and faulting, geological advice may be the means of saving many thousands of dollars. This saving may be effected in several ways, as illustrated by the following examples: A coal-mining company built a railway spur about eight miles long and erected elaborate surface equipment to care for a large tonnage before discovering that the coal bed had been displaced by a fault and the coal which had been supposed to underlie a large part of the property had been greatly uplifted and long since destroyed by erosion. In the anthracite region where there has been complex folding and thrust faulting much useless prospect drilling has been done, because the character of the folds and faults was not understood. A contracting company engaged in stripping, and which has been unusually successful, owes much of its success to its superior knowledge of geologic structures.

The problem of correlating the various beds of coal is of much economic significance in many places and has resulted in much court litigation. Correlations based on geological evidence are usually more valuable than those that deal merely with quality and thickness of the beds.

Geologists now know fairly well the coal-forming periods of North America and the distribution of the commercial coal deposits, so that they are able to give competent advice to persons seeking for coal. Although this information has been given a great deal of publicity for many years, nevertheless much money has been spent in efforts to locate commercial deposits of coal in most unlikely areas. Several of these in eastern Pennsylvania that have come under my observation are the result of failure to distinguish between black shale and decomposed coal such as develops at the outcrop. Because an outcropping bed of coal is known to improve as it is followed into the hill, the conclusion is general that a black shale bed at the surface will pass into coal if continued under the cover of other strata. Other related assumptions arise from the occurrence of thin coal lenses a few inches in thickness in the Pocono sandstone of the northern Appalachians. The coal is of good quality and therefore naturally stimulates search for beds of commercial thickness. Though the geologist cannot explain why coal-forming swamps such as developed during later periods did not exist during Pocono time in Pennsylvania, he can say that they did not, and therefore money expended in search for coal in the Pocono sandstone is unwisely spent.

Of domestic non-metallic economic mineral products, some occur in definite beds or strata, whereas others are in the form of veins, irregular masses, or pockets bearing little or no relation to the surrounding rocks. As examples of the former, coal, limestone, sand and sandstone, clay, slate, and rock salt may be mentioned, and of the latter, mica, feldspar, quartz, barite, fluorite, most magnesite deposits, and many others. Of fundamental importance is the determination of the mode of occurrence, and seldom are glaring mistakes in relation to this matter made. Some are made, however, and therefore mention is made of them. In this connection, perhaps, geologists are to be criticized at times for their rather positive statements as to the occurrence of different products. As an instance, one may cite the bedded deposits of magnesite in the state of Washington that seem to have been long overlooked largely because this mineral was not supposed to occur in beds associated with the sedimentary rocks.

Here and there geological advice has been sought in the search for many of the non-metallic products such as clay, sand, mineral paints, mica, feldspar, graphite, and other products, but to the great number of operators of these materials geology has not been regarded as of practical value. Search for these products and also their exploitation would frequently have been greatly facilitated by the application of geological principles. Most of the deposits of these materials vary greatly in quality. Whereas some of these variations are not such as can be predicted, others bear such relations to the surrounding rocks or the structure as to furnish the geologist with valuable clues for locating and following the deposits of economic importance. The problems to be encountered are so varied as to forbid description in this article.

Until recently, little interest in geology was shown by operators in the stone industry, but I have had occasion to observe here a growing appreciation of the usefulness of the subject. These observations seem worthy of presentation and furnish the main purpose of this article. The illustrations are mainly from the cement industry.

Even down to the present, one can find cement operators who cannot fully realize that rocks occur in definite beds that usually have considerable areal extent in proportion to their thickness and that a particular bed or series of beds represents a definite period of time during which it was formed, and a distinctive type of deposit. They fail to interpret the evidence that is all about them. Only a few suggestions from a geologist are required to show any quarry operator that the product he seeks is not confined to the strata that are exposed at the surface, and, on the other hand, to point out that a particular kind of rock has its limitations and what these boundaries are.

Underlying and overlying strata, representing earlier and later periods of time and other conditions of deposition, possess peculiar characteristics. Simple and trite though this statement may seem to be, one can find plenty of examples that indicate the manner in which these principles have been overlooked or ignored. The reason, often, is that the strata do not appear at the surface continuously, they being covered by an overburden of soil, rotten rock, and other débris, and the further fact that rotten or decomposed rock and residual soil may bear little resemblance to the original or fresh material also tends to confuse. Beds of stone under these conditions are not readily traceable, and are even more difficult to trace when they have been folded intricately and subsequent erosion has removed the tops of the folds.

In a discussion of the value of any article, process, or method, one can either describe the benefits derived by its use or the losses resulting from its non-use. The latter method is adopted here to prove the value of geology in the stone industry, inasmuch as many illustrations are at hand. For obvious reasons, names of companies are omitted.

When, in 1869, David O. Saylor, the father of the American portland cement industry, was carrying on his experiments to imitate the English portland cement that was being imported into this country in continually increasing volume, he happened by pure chance to

find in the Lehigh Valley of eastern Pennsylvania an argillaceous limestone with approximately the chemical composition later found most serviceable for the production of the best grade of portland cement. He established the first portland cement plant on the west side of the Lehigh River, and that is where the second and also the third plants were located, on properties closely adjoining. He and the other early operators did not realize that the rock which they were using constituted a series of beds several hundred feet thick that outcropped in a continuous band from ¼ mile to 2 miles in width throughout the valley. They remained therefore in the locality where the operations were started and overlooked the most promising properties lying on the other side of the river, only a few miles distant, leaving them for the later comers.

In the cement industry perhaps the majority of mistakes have been made in the preliminary stages. One company builds its plant on the very spot underlain by the best stone, which at some later period is badly needed; another dumps its surficial waste product on the good stone and must later rehandle this material or abandon the quarry; another, seeking a continuation of the stone worked or another deposit of similar character, conducts an extensive exploration by means of drilling and locates the holes in such a way as to obtain relatively little useful information, or obtains the necessary data only by many needless holes and consequently much additional expense; another finds a few rocks exposed that seem to possess the characteristics of those sought, and purchases an extensive property or puts up a plant to use the material, only to learn later that the good stone is intimately mixed with much of poor quality; another opens a quarry in the wrong manner because the trend of the strata is not known, and the quarry costs are excessive; and still another overestimates the amount of stone present and makes plans and incurs expenditures that are not justifiable. These are not hypothetical cases, but actual statements of conditions that I have observed, and numerous concrete examples might be given. In each instance financial losses, and in certain cases disasters, have resulted.

A second series of blunders have resulted from the failure to recognize the fact that in many, if not most, regions the beds or strata are not in the horizontal or approximately horizontal position in which they were originally deposited. Some have been slightly tilted, some have been turned on edge, in some formations beds have been folded as intricately as one could fold a series of sheets of paper, and elsewhere the strata have been broken and displaced so that the beds are no longer continuous. If the overburden forms a more or less complete blanket, to follow beds from place to place is exceedingly difficult. Even the trained geologist is occasionally confronted with problems of this kind which he is unable to solve definitely without additional information obtained by trenching or drilling. A few outcrops, however, may enable him to reach sufficiently exact conclusions to make possible the location of the continuation of the beds with a minimum expenditure of effort and money. A few illustrations of mistakes of this nature may be set forth here. A company, in the development of its quarry, found that the beds terminated abruptly, and it had to expend considerable money to locate the continuation. An examination of the outcrops by a geologist revealed a fault by which the strata had been offset and demonstrated the improper location of the quarry.

A company purchased a property for the location of a cement plant and proceeded to test the character of the stone by vertical-well drill holes, even though the strata were inclined so steeply as to be approximately vertical. The result was that each drill hole scarcely tested more than one stratum of rock, and that was not much thicker than the diameter of the drill hole. The company purchased several farms and formed plans to erect a mill, but before doing so employed a geologist to examine the property. He directed exploration by means of a few diamond-drill holes set at an angle approximately perpendicular to the bedding planes, thus furnishing samples of all the beds that would ultimately be worked. This investigation revealed the presence of much interbedded rock entirely unfit for portland-cement manufatcure, which was concealed at the surface by the soil cover. Needless to say, the cement plant was not built.

A party located stone of desirable quality on a well-situated tract and estimated from the width of the outcrop that with a quarry 200 ft. in depth enough stone could be obtained to manufacture 40 million barrels of cement. If the strata had been vertical the estimate would have been fairly accurate, but as the beds in much of the property dipped at angles less than 45 deg., and as the desirable strata were both underlain and overlain by other beds of unsatisfactory quality, it was easily shown that the amount of stone estimated could be obtained only by resorting to mining or by the removal of an excessive amount of the overlying poor stone. The project was abandoned as having little chance of proving profitable.

A company put down a few holes in a place where the strata were badly folded and faulted and assumed that these furnished information concerning the underlying strata across the entire area, whereas the complicated structure made such assumptions grossly inaccurate.

In recent years much has been written in regard to the mining of limestone, and a number of profitable limestone mines are now in operation. That the geological structure is perhaps the most important factor in determining whether to mine or not is certain. The great obstacles are broken rock and folded or faulted beds. If the strata have been greatly folded or faulted, the rock will be so shattered as to make a large amount of timber necessary, and I do not know of a single place where limestone mining has been profitable under these conditions. Further, the mining becomes unduly expensive if decided and frequent changes in the dip of the beds occur, such as where there has been much folding or other disturbance of the strata. Anthracite and other products are mined under these conditions, but the selling price is much greater than that of limestone. If the mine is not so located as to be self-draining, a region of shattered limestone permits such free passage of underground water that the cost of pumping is prohibitive. I know of one property where the complicated folding of the strata resulted in such high mining costs that the mine was closed, and another instance where underground mining was recommended by a mining expert, but the mine was not opened when geological investigations revealed the obstacles that intricate folding and faulting had created.

Under many conditions wider experience than that usually possessed by the quarry foreman or superintendent is required. The geologist is then much more necessary. Rocks of much the same appearance may be essentially different in chemical composition, and vice versa. In the greatly folded region of the Appalachian province the same series of strata may have undergone such changes in certain fields as to make their correlation with the same beds in other fields uncertain. A quarryman in search of a particular kind of stone with which he is familiar may fail to recognize it when it has undergone metamorphic changes by which some of its physical and chemical characteristics have been changed without altering others. The bituminous and anthracite coal beds of Pennsylvania are of the same age and were doubtless at one time connected. By great compression during the folding of the strata the eastern coal beds were converted into anthracite, whereas the regions of gentle folding contain beds of coal not advanced beyond the stage of the bituminous. Mud deposits of the same formation may be shales in one locality and slates in another. Calcareous beds of the same period of deposition are ordinary limestones in one place and coarsely crystalline marbles in another. In general, almost all kinds of rocks assume

quite different characteristics when subjected to intense compression with accompanying heating, and even within comparatively short distances the degrees of alteration may be radically different.

The importance of recognizing rocks of similar origin and chemical composition although of different physical appearances may be realized by considering one illustration. A band of high-grade cement rock belonging to the same formation previously extensively worked in another part of the State, and most favorably located, was long overlooked because a high degree of metamorphism accomplished by intense compression had so altered its appearance that it was not recognized. Chemists and professional quarrymen had failed to identify the true character of the rocks, and only the investigations of a geologist familiar with these changes revealed the actual situation. A successful cement plant is therefore now in operation in a desirable location where other cement companies maintained that no suitable stone was present.

Every person who works with rocks of any kind soon learns that homogeneity does not exist over wide areas. The lack of homogeneity pertains to the thickness of the beds, the different composition of successive beds or different parts of the same bed, the appearance or disappearance of certain beds without any change in the others, the shattered or crumpled character of certain portions of the beds without change in the other parts, the decomposition by solution or decay of particular sections, as well as other changes that might be mentioned. The practical significance of these phenomena may be observed in almost every quarrying region. The problem may be and usually is that of deciding whether the changes or variations are local or widespread, and consequently whether to proceed through the places where adverse conditions prevail or to abandon the project. In some instances, operations have been continued far beyond the profitable stage with the vain hope that favorable conditions would again be found. In others, projects have been too quickly abandoned on encountering unfavorable conditions, as phenomena of local character have been interpreted as widespread. In many of the instances mentioned the investigations of a trained geologist would determine the real character of the problem, although admittedly at times he, too, may be baffled. He should, however, be able to recommend the best and cheapest method by which the necessary facts, on which a correct decision might be based, can be secured if the evidence in hand is insufficient.

One cement company in its work encountered a clay-filled depression and stopped work in that part of the operation and quarried stone here and there in other parts of the quarry where the rock was decidedly inferior. When the geological import of the situation was understood, the local clay pocket was excavated and the quarry again advanced in the direction of the best stone and with very considerable financial profit.

The fact that the mistakes mentioned in the foregoing were actually made is sufficient justification for calling attention to them. A favorite trick of the fake promoter is to direct attention, mainly if not entirely, to the favorable features of any project and to ignore the unfavorable ones. To a lesser degree, other persons frequently display an undue amount of optimism which may lead to reckless expenditures in the stone industry. The economic geologist after some years of practical experience in which he has opportunities to observe many instances where money has been needlessly expended is almost certain to adopt the opposite attitude either consciously or unconsciously. Although he should not be regarded as pessimistic, he surely in time becomes conservative. He observes and notes all the favorable conditions, but makes his most careful investigations to determine any adverse conditions and does not assume their absence until definite proof has been obtained. Perhaps at times he may be unduly conservative, but when millions of dollars of other peoples' money may be expended on his recommendation, conservatism is a virtue Investing companies have emphasized the fact, over and over again, that the great majority of proposed mining and quarrying projects have little chance of being profitable, and therefore that a geologist must make so many adverse reports is not surprising.

Just as persons generally call in the physician only when serious sickness occurs, so quarrymen all too commonly seek professional advice only when disaster impends. In some regions, the fact that geologists can render service is not known, although the greatly increased demand for their assistance is encouraging. Unfortunately, the geologists sometimes called in are incompetent and have themselves made expensive mistakes, but this cannot be helped. The medical profession suffers in the same way in spite of all the legal and professional safeguards that have been thrown about it. A person in any line may be called in to assist in a case where he realizes or should realize that his training and experience are inadequate. Here is where he should and perhaps usually does request the calling of another for consultation. In the medical profession a life may be at stake; in the quarry industry financial success or failure. Of course, the consultant should be one who has had the experience demanded for the particular problem.

The geologist interested in the promotion of his science expects to be consulted when difficulties have actually been encountered, yet he greatly prefers to be consulted before trouble develops. Although he can be of assistance at any stage, his services are more worth while in the first stages of an industrial development.

Probably a long period will elapse before geologists will be generally consulted in the exploration and early exploitation of the products obtained by quarrying, although many instances could be cited in which this is being done. Gradually, geology is being applied in the quarrying industry, just as it has been in the oil and gas industry.

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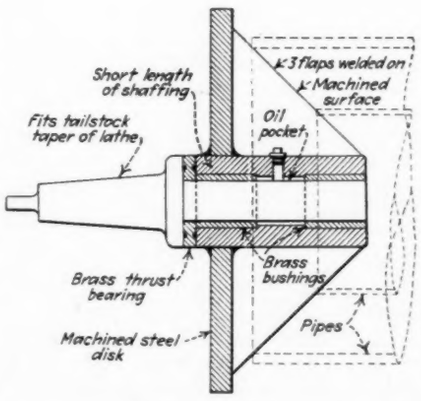
All-Steel Pipe Center

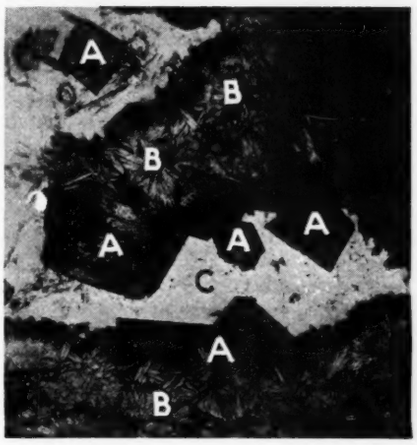


Detail of practical pipe center made from scrap

Cutting and threading large-diameter pipes in a lathe is difficult, and requires time, if a practical pipe center is not available for rapid centering of the pipe, resting between the lathe chuck and the dead center. W. Lightfoot, shop foreman of Uvalde Rock Asphalt Company, Blewett, Tex., overcame this difficulty by the use of the simple pipe center shown in the accompanying sketch. It consists of a stationary shaft with the taper end secured to the tailstock spindle, and an all-welded revolving body, fitted with two brass bushings and three machined centering and holding flaps. A brass thrust bearing rests between the shaft flange and the hub face of the revolving body. All parts were made from scrap material.

The Genesis and Metallurgy Of Cornwall Ores

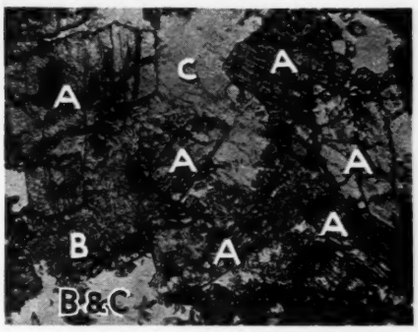
E. H. Davison



Photomicrograph of quartz-chlorite-cassiterite veinstone from the Mount Caribis mine, Redruth, Cornwall. Mag. 25. "A," cassiterite; "B," chlorite; "C," quartz.

CORNWALL has long been noted for its production of tin and copper; but arsenic, wolfram, lead, zinc, silver, uranium, radium, iron, manganese, antimony, nickel, and cobalt have also been produced there; in fact the county, for its size, is one of the most highly mineralized areas in the world.

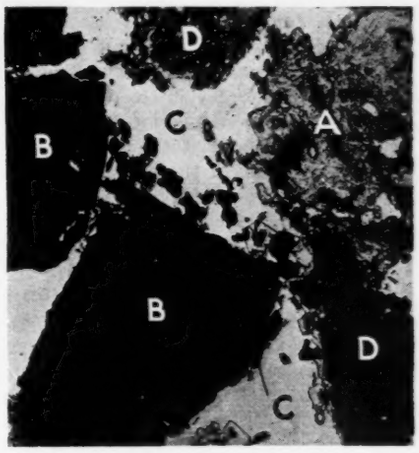
The lodes or veins in Cornwall occupy fissures in the granite and overlying slaty rocks that resulted from crustal movement. These fissures run in four main directions, the majority striking north of east. They cut the granite, slates, porphyry dikes, and basic intrusions, and are thus younger than these rocks, probably having been formed in early Permian times. Evidence indicates that the metallic minerals of the lodes were derived from the granite magma. Analyses show that the granite invariably contains cassiterite in small amounts, and also occasional patches of arsenopyrite and chalcopyrite. The pegmatite veins and porphyry dikes also contain such minerals as cassiterite, wolframite, arsenopyrite, and molybdenite. Some veins, at considerable distances above the granite surface, are filled with granite material mixed with the usual metallic and gangue minerals. The lodes also contain tourmaline, axinite, topaz, fluor-spar, fluor-bearing micas, some of which can be formed only under conditions of high pressure and fairly high temperature.



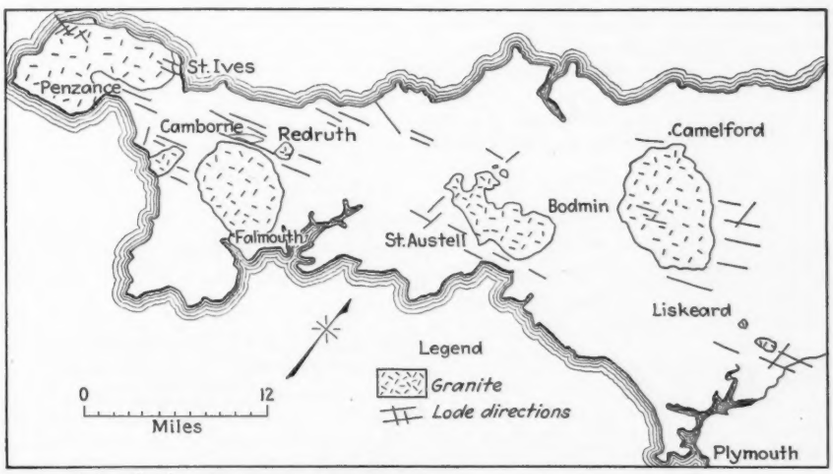
Photomicrograph of quartz-chlorite-cassiterite veinstone from Wheal Kitty, St. Agnes, Cornwall. Mag. 25. "A," cassiterite; "B," chlorite; "C," quartz.

Certain altered types of the country rock are also almost invariably associated with the lodes. In the granite the fissures are flanked by such alteration types as tourmalinized granite or schorl rock, in which the feldspar and dark mica of the granite have been partly or completely altered to quartz and tourmaline; greisen, in which the granite is altered to a quartz white mica, and topaz rock; and china-clay rock, in which the feldspar of the granite has been kaolinized.

In the slate the chief altered rock types alongside the lode fissures are tourmaline slate, in which the aluminum silicate of the slate has been altered to tourmaline; calc flinta, in which calcareous slate has been altered to a calcium silicate rock with such minerals as axinite, garnet, and zoisite; and silicified slate, in which the rock has been impregnated with silica. All these types of alteration suggest the action of watery, siliceous solutions.

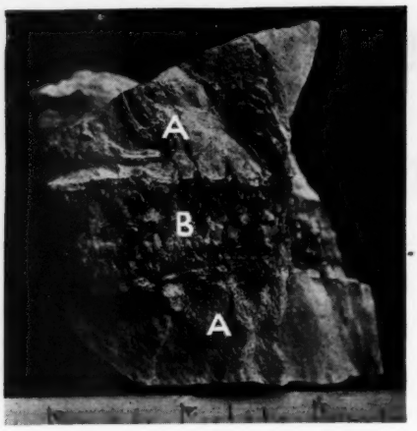


Photomicrograph of quartz-arsenopyrite-wolframite-cassiterite veinstone from East Pool mine, Redruth, Cornwall. Mag. 25. "A," cassiterite; "B," arsenopyrite; "C," quartz; "D," wolframite.



Sketch map of the Cornwall mining district

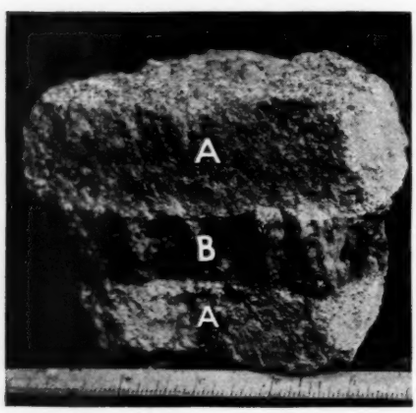
Many theories have been advanced to account for the filling of the lode fissures with metallic and other minerals. Among the earliest was one which suggested that the lode contents were brought there by meteoric water percolating from above; then followed



Veinstone with cuprite, malachite, and native copper in slate. From the Gwennap United Mine, St. Day, Cornwall. "A," altered slate; "B," quartz with cuprite, malachite, and native copper.

the lateral-secretion theory, which gave the credit to water passing laterally from the country rock to the lode fissures, leaching the metals from the country rock and depositing them in the fissures. Another theory maintains that electrolytic action accounts for the lode filling. These theories were developed in sequence as mining became deeper. The meteoric theory explained many features of the oxidation zone of the lodes; the lateral secretion theory explained many phenomena of the zone of secondary enrichment.

When deeper levels were reached, however, a close connection was evident between the filling of the lode fissures and the intrusion of the granite magma. This, shown by the phenomena mentioned in the foregoing, gives rise to the most recent theory, which attributes origin of the lodes to the action of magmatic solutions that rose through fissures resulting from previous crustal movement; and, while under pressure, deposited minerals and brought about alteration in the surrounding rocks. This theory is sometimes referred to as the pneumatolytic theory; but, as

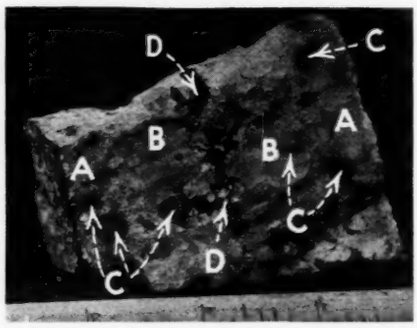


Quartz-cassiterite vein in granite. From Bunny mine, St. Austell, Cornwall. "A," kaolinized granite; "B," quartz and cassiterite.

actual evolution of vapor may be doubted, considering the pressure that existed, to conceive an intrusion of watery magma highly charged with volatile constituents is more logical.

The metallic minerals of the lodes are arranged in a series of primary zones, their position being determined by the level of the granite surface, which, at the time the lode filling took place, must have determined the temperature of the rocks above it. These primary zones have been studied by geologists and found to occur:

1. In the slates, well outside the metamorphic aureole of the granite, the lodes containing (*a*) hematite, limonite, siderite, pyrites, marcasite, and pyrolusite, with calcite and quartz; followed below by (*b*) galena, sphalerite, minerals



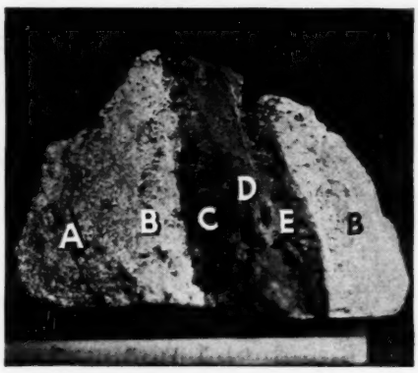
Lead-zinc vein in slate. From Tamar Valley mine, Devon, Cornwall. Sphalerite in chalcedony on walls of vein, with a center of fluorite containing sphalerite and galena. "A," chalcedony; "B," fluorite; "C," sphalerite; "D," galena.

of uranium, nickel, cobalt with chalcedony, dolomite, pyrites, and fluorite.

2. In the metamorphic aureole, from well above the granite surface to just below it—chalcopyrite, wolfram, arsenopyrite, quartz, fluorite, jasper and chlorite, with some cassiterite toward the bottom of the zone.

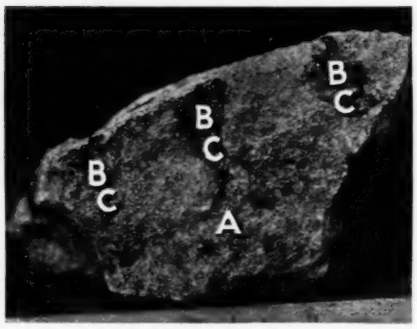
3. From just above the granite surface to a depth of at least 3,000 ft. in the granite—cassiterite, arsenopyrite, wolfram, quartz, chlorite, and tourmaline, sometimes with specular hematite. Thus, the zone at which the land surface truncates the lode depends on the position of that point relative to the granite surface.

The lode contents, however, are not so simple as they might at first appear.

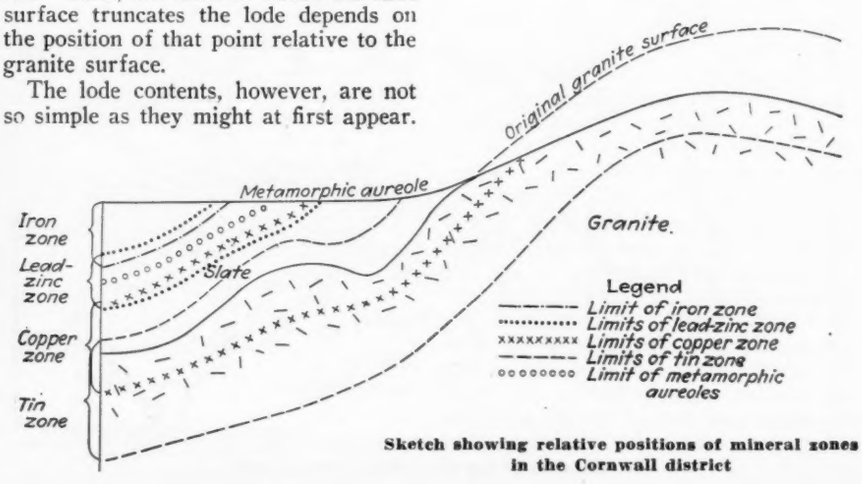


Cassiterite-tourmaline vein in greisened granite. From Wheal Basset, Redruth, Cornwall. "A," granite; "B," greisened granite; "C," cassiterite; "D," quartz; "E," tourmaline.

Meteoric water finds its way down the lodes, and so zones of oxidation and secondary enrichment are superimposed on the primary zones, which often results in lodes of complex composition. Thus in the upper part of a copper lode are found oxidized ores of copper, such as the usual carbonates with such minerals as olivenite, libethenite, pharmocosiderite; and a little lower down, reduced minerals such as native copper and cuprite; still lower is an enrichment zone of complex copper sulphides. The primary copper minerals are chalcopyrite and perhaps bornite and chalcocite; the primary mineral of tin



Greisen with veinlets of cassiterite and fluorite. From St. Dennis, Cornwall. "A," greisen with gilbertite and fluorite; "B," cassiterite; "C," fluorite.



Sketch showing relative positions of mineral zones in the Cornwall district

is cassiterite; stanite occurs occasionally but is not of economic value.

As the tin ores are concentrated almost entirely by gravitational methods, the size of grain of cassiterite in the crushed ore is an important factor. The methods in use in Cornish dressing plants enable tin ore to be concentrated when the size of the cassiterite particle is as small as 50 μ (0.050 mm.); below this size concentration becomes difficult, and cassiterite grains below 20 μ (0.020 mm.) are difficult to concentrate. The size of the cassiterite in the original ore is therefore an important factor, as is also the nature of the veinstone containing the cassiterite.

The upper part of the veinstone carrying tin is filled with quartz and chlorite as the chief gangue mineral, and is thus easily disintegrated without too much fracture of the cassiterite grains, which are usually of fairly coarse grain (about 1 mm.), so that such a veinstone can be concentrated easily and economically. As the tin lode is followed downward, the chlorite is gradually replaced by tourmaline; eventually the veinstone becomes a breccia of fragments of quartz, full of microscopic needles of blue tourmaline, and containing some cassiterite, the fragments being cemented by quartz and cassiterite. This type of ore, more difficult to crush than the chlorite veinstone, needs to be more finely ground in order to free the cassiterite from the gangue. It is, therefore, a difficult type of ore to concentrate efficiently, because of the large proportion of slime produced. Given an equal assay value for the two ores, one coming from the upper part of the tin lode will be more profitable than one from the lower part.

Associated minerals found with the cassiterite are also of importance, the chief being arsenopyrite, wolfram, and chalcopyrite. The first of these is separated by calcination, the arsenic being obtained as AS_2O_3. Wolfram is separated by magnetic means; the chalcopyrite is isolated on the dressing table, or leached from calcined ore and precipitated on iron. The arsenic oxide, wolfram, and copper so obtained form valuable byproducts.

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Standardization Urged For Rock-Drill Discard Tolerance

DISCARD TOLERANCES of important working parts of rock drills used in the mines of the Witwatersrand have to be closely gaged to determine the amount of permissible wear consistent with high efficiency before discard of the part is advisable, writes an engineer on the staff of one of the large companies. In 1930 one group of mines spent about £23,000 in new rock drills; and in spare parts, £215,000. Replacement of spare parts is normally at the discretion of the rock-drill mechanics, who usually work to no definite standards beyond judging wear by estimating slackness. Micrometer gages are seldom used, and no generally accepted proved set of standards is available. Investigations reveal a lack of consistency in the amount of wear permitted. The following table gives discard tolerances of four important machine parts, as applied to one type of drill:

	Wear Before Discarding		
	Minimum, Inches	Maximum, Inches	Discard Range, Inches
Valve	0.0005	0.0055	0.005
Valve bushing	0.001	0.010	0.009
Front cylinder washer	0.0045	0.012	0.0075
Cylinder (before regrinding)	0.0035	0.007	0.0035

Such a range means the discarding of worn parts that would, if used, still function efficiently, and the retention of worn parts that should be replaced. Some parts of one type or make of machine are interchangeable with those of another make. Worn parts discarded from one make could efficiently be used in the other make. Standardization of discard range of machine parts that are interchangeable with different makes of machines would reduce cost of replacements, adding longer life to the machines, giving thereby high rock-drilling efficiency, our correspondent maintains.

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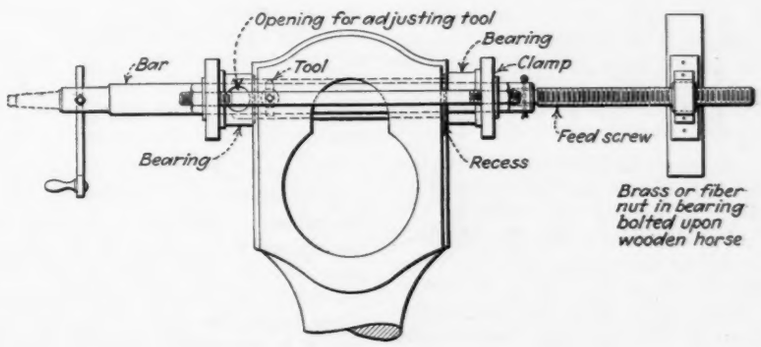
Device for Boring Worn Keyholes

LOOSE BEARING KEYS on connecting rods often cause trouble in the power house. If not attended to, the keyholes will become pitted, and the keys may break. To avoid such difficulties the keyhole must be rebored and a new key made to fit the new dimensions. Reboring of the hole can be done in a horizontal boring mill, at the shop, or, if no such machine is available, with a hand or power-driven boring device, in the power house. The boring rig shown in the accompanying sketch is used in the power house of Nevada Consolidated Copper, Hayden, Ariz., for reboring Corliss valve chests and keyholes. It consists of a long boring bar; two cast-iron bearings, held in place by two crossbars and two tension bolts; a feed screw, 60 threads per inch, attached to the end of the boring bar by a cotter pin; and an adjustable bearing-like feed-screw nut of brass or fiber, which is bolted to a support of wood, or angle-iron, anchored to the floor. The bearing on the drive end has an opening for adjusting and tightening the boring tool.

In this device no gear transmission is required, as only fine cuts are made. The boring rig can be actuated by hand or by an electric motor.



Economies and Efficiencies in Mine and Plant—II

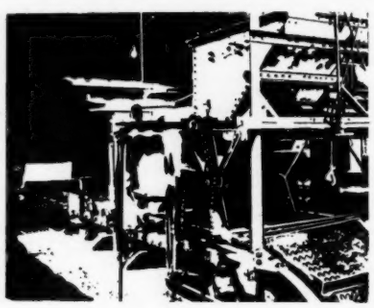
A. H. Hubbell
Associate Editor

WHERE milling is planned, two striking achievements, of recent date, are worth attention. One is the act of the Empire Zinc Company at Gilman, Colo., in placing a mill entirely underground. This mill is unofficially reported to be of about 500 tons' capacity. The manager avers that the company's experience elsewhere had shown that under good rock conditions and with proper facilities for drilling, blasting, and removal of débris, it was cheaper to prepare a given volume of shelter by hard-rock excavation than by permanent wall and roof construction. Possibly this statement has qualifications not immediately evident, and no doubt the severe climate and high altitude (just over the Continental Divide), as well as the relation of the mill "site" to the near-by canyon, were influencing factors. At any rate, it affords a precedent that deserves consideration when milling facilities must be provided. What problems of maintenance will arise only time will show.

Centralization of milling operations for several tracts, or leases, in one plant —this in the Tri-State district at the new Bird Dog mill—is the second achievement referred to in the foregoing. To understand its import one must be familiar with the peculiar conditions that have long characterized zinc mining and milling in this region. Until this venture of the Commerce Mining & Royalty Company, operations had customarily been conducted on a relatively small scale on account of the large number of mineral tracts and necessity of milling the ore from each one by itself. That central milling will in general permit new economies can unquestionably be accepted. Curtailment of operations, since the Bird Dog started, prevents any worth-while comparison of milling costs, intermittent operation in runs of limited duration having thus far given excessive overhead and power costs. The idea is spreading: The Eagle Picher company, in the same district, has already begun construction of a large central mill which will replace all of its smaller plants.

As the chart in Part I clearly shows, almost half of the functional operations involved in mining and treating ores and mineral products are classifiable as treatment or processing functions. One might read from this chart, moreover, that opportunity exists for the further application in treating non-metallic products of processes and equipment developed in metallurgical work.

Many crushing and grinding flowsheets are susceptible of improvement, judging from observation of numerous existing plants, in the light of what has been done at others. The cone crusher has simplified many flowsheets and indirectly lowered milling costs. It has effected savings through eliminating accessory rolls and other units; and, by the greater reduction in one unit which it makes possible, has stepped up the



capacity of the grinding mills and other units following it. For example, in one plant a 7-ft. cone crusher replaced a No. 8 gyratory and a horizontal disk machine in series, which had been crushing 134 to 140 tons per hour to a maximum of 1½ in., the new unit substituted yielding a much finer product at 200 tons per hour. In another plant, two 7-ft. cone crushers replaced nine separate crushing units.

About a year ago, Climax Molybdenum Company, operating in Colorado, completed a new crushing plant. In this, cone crushers replaced a set of rolls formerly used. Comparative crushing costs are as follows:

Year	Tonnage	Cost per Ton
1928	321,448	$0.175
1929	411,344	0.152
1930	414,449	0.174
1931	223,863	0.056

The tonnage and cost given for 1931 is for six months' operation, June to November, inclusive. Consequently, the company has charged off major repairs for the cone crushers in advance (although the plant is entirely new and there have thus been few repairs), so that it is reasonably sure that costs will eventually stabilize around 6c. per ton. Further, according to W. J. Coulter, general manager, the product from the old plant used to be a "poor 1-in." size, whereas that from the new plant is running 15 per cent on ⅜-in. mesh. Just how much credit is due the cone crushers in getting the lower costs is hard to say, but Mr. Coulter estimates it at 7.5c. per ton.

Another instance of crushing economy may be cited from the practice of a Tri-State plant, where hard-iron rolls, so-called locally, were replaced by a 7-in. suspended gyratory, with an estimated saving, in hard-iron consumption and power, of $3,695 per year of 300 ten-hour working days, when running at an average crushing rate of 100 tons per hour. This type of crusher has also been applied in Russian asbestos milling.

Proper feeding has a direct effect on the efficiency of crushers and other units following them in the flowsheet. An excellent example of this is afforded at the plant of the Canada Cement Company, near Montreal. Here the installation of an effective chain feeder in front of a roll crusher, which was receiving 12-ton skip loads directly, did away with all irregularities in the flow of feed, and so increased the effectiveness of subsequent operations that a net increase in output of 27.5 per cent resulted.

Closed-circuit fine grinding, permitting control of grinding and its cost, has finally made its entry into the cement industry, where its adoption for grinding prior to sintering may be expected to widen rapidly, owing to its marked superiority over the present established practice. Today, most cement rock is being ground in open circuit mills to about 97 per cent minus-100 mesh, with a power consumption of about 16.5 kw.-hr. per ton. In contrast, the average ore-dressing practice, in plants treating porphyry copper ores, accomplishes a 100-mesh grind with a power consumption of only 10 kw.-hr. per ton.

Silica grinding affords instances of cost reduction. The industry in southern Illinois, which formerly used wet grinding in chaser mills, has introduced wet grinding in tube mills as well as improved dry-grinding methods. The Potters Mining & Milling Company, East Liverpool, Ohio, by reconstructing half of its batch-type mill and installing an 8x10-ft. ball mill and air separator,

cut its electric power cost for grinding approximately in half, other costs remaining the same, and improved the quality of its product.

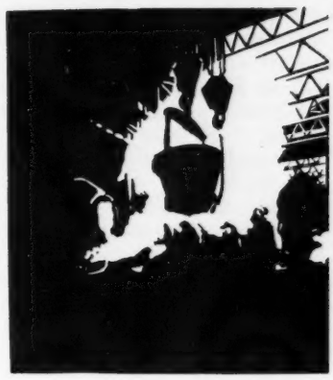
At the sand and gravel plant of the Kaiser Paving Company, Oakland, Calif., the management feels it has made a distinct gain in adopting what might be termed up-to-date ore-dressing practice, involving the use of a cone crusher, vibrating screens, and rake classifiers, for preparing its products for market. Other instances might be cited. In many plants, vibrating screens are being substituted for trommels, with a resultant decrease in power costs and a great increase in capacity.

Hydraulic classifiers have been used with remarkable success in washing ocher, to remove sand, supplanting the wasteful and inefficient practice of settling out the sand in troughs, which are still employed in places. Three such classifiers, installed in the Cartersville district, Georgia, a few years ago, paid for themselves in the first year of operation. That this equipment has not been adopted more widely for this purpose is most surprising. Dry centrifugal air separators have also attracted attention for removing sand and other impurities from clay. They are said to have been used most successfully in treating paper clays.

Flotation, once limited to treating metallic ores, is making itself useful in concentrating certain non-metallic minerals, particularly phosphate rock, fluorspar, and barytes. Other non-metallic minerals—bauxite, mica, kaolinite, and feldspar—have been floated on a laboratory scale, giving hope of future commercial application, to the benefit of the industries concerned.

As with flotation, so with magnetic separation, by means of which many difficult separations can be effected. Aside from its usual application, it has been used in concentrating manganese ores, cryolite, and stellite (separating this hard-facing alloy from steel), and also for removing fine flour of iron and iron oxide from feldspar, glass sand, borax, and similar materials. In performing its function of keeping tramp iron out of crushers and other equipment, it has been cheap insurance. One feldspar mill, now using crushing rolls instead of pebble mills—which feldspar grinders have long used to the exclusion of all other kinds of reducing equipment—has almost wholly removed all contaminating materials (iron, garnet, pyrite, hematite, tourmaline, biotite, and muscovite) from the feldspar, thereby producing a pure and free-flowing granular product, almost dustless, as compared with the pebble-mill product running about 50 per cent minus-200 mesh.

Experience and knowledge gained in concentrating non-ferrous ores are being increasingly drawn upon in the work of beneficiating iron ores. Lower and



lower grades of ore are steadily being brought within the commercial limits. Methods of preparation formerly employed, involving such functions as coarse crushing, log washing, trommel screening, tabling and jigging, though not all of these necessarily in one plant, have been amplified by the introduction of bowl classifiers, secondary crushing, and abrasive screening, also hindered settling classification, with flotation at present in the background. Sintering has also been successfully applied. In all these improvements, the objective primarily has been greater recovery. Decrease in cost, save on a basis of ton of concentrate produced, is said to have been a negligible factor. In fact, the introduction of secondary crushing resulted in an increase in cost, though giving a higher recovery. Information as to iron ore beneficiation costs is scanty. Exceedingly heavy taxation and watchful fee owners are largely responsible for this condition. Nevertheless, lower and lower grades of ore are gradually being brought within commercial limits. To find ways of utilizing much of the low-grade material will require many years.

Beneficiation of iron ores is simple compared with some of the more complicated metallurgical processes used in the non-ferrous field. And related to the matter of utilizing low-grade ores is that of re-treating tailings and residues. Both phases are touched upon in the succeeding notes.

Metallurgical research at the United Verde mine, in Arizona, is being concentrated on the problem of making a more complete recovery of the mineral contents of the ore, in particular zinc, containing which metal the mine has large tonnages of ore. Market conditions and lack of adequate cheap power prevent its extraction at present.

Boulder Perseverance gold mine, at Kalgoorlie, Western Australia, by using a bromo-cyanide method of ore treatment which eliminates roasting, expects to reduce costs per ton to 10s. (of which fine grinding, agitation, and vacuum filtration will be the principal items) on a 250-ton basis, as compared with 12 to 15s. per ton when roasting previous to cyanidation. Time of agitation will be reduced from 16 to 3 hours, and 90 per cent of the gold will be recovered. The process is old, having been formerly applied to telluride ores in Australia and elsewhere. Flotation is also being introduced at the Chaffers mine, Kalgoorlie, the concentrate being roasted before cyaniding, in evident expectation of added profit.

A striking instance of tailing retreatment is to be noted in the same district. This was the erection of a £34,000 plant, of 40,000 tons' monthly capacity, to treat a 2,500,000-ton dump averaging 7s. 10d. per ton, of which 45 per cent was recoverable. A quarter of this tonnage has thus far been treated at a cost of 2s. per ton and a total profit of £40,000. Treatment is simple, involving sluicing with monitors, agitating with cyanide, continuous filtering, and gold precipitation.

Huge accumulations of tailings from cyanidation at the gold mines of the Rand, South Africa, would appear to offer attractive opportunities. Likewise the vast tonnages of imperfectly leached nitrate residues in Chile, when economic conditions improve. In the Michigan Copper Country, moreover, all producing companies have on hand large tonnages of amygdaloid tailing sands, which, according to estimates, can be treated at 22c. per ton, including regrinding and flotation, with an expected average recovery in many cases of 6 lb. copper per ton.

Another instance of the utilization of waste is the leaching by Phelps Dodge, at the Copper Queen, of a 9,000,000-ton waste-rock dump, averaging 0.26 per cent copper per ton. The work, begun late in 1929, yielded over 4,000,000 lb. of copper by March 1 following. Leaching of caved ground, likewise, is thought to have possibilities greater than usually considered. Still another instance of waste utilization is that of the Amador Metals Reduction Company, in California, which has installed a classifier, a leaf filter, a dryer, and a sacker for preparing tailings of the Argonaut mill for oil-well work.

Many low-grade zinc products, formerly regarded as waste, are viewed as having possibilities of profit. These include zinc slag at Broken Hill's Port Pirie smelter, Australia, containing 18 per cent zinc, according to Kurt R. Goehre; pyrite cinder dumps in Germany, too high in zinc to be used in blast furnaces; low-grade calamine deposits; Canadian complex lead-zinc-copper ores; and residues from retort and electrolytic plants and brass furnaces. Various processes, including the Waelz, Laist, Coley, and Follsain, have been developed for treating slag and low-grade products. According to a Bureau of Mines researcher, use of methane may permit lowering of zinc reduction costs. The fuel-reagent expense of the process is said to be equivalent to coal at $1.20 per ton.

Investigations of the present method of fire refining of copper indicate that use of steam instead of air for removing impurities would take less time, cost less, reduce amount of poling and possibly eliminate it; and that finely divided reducing material and steam are better than poles for deoxidation and are rapid and low in cost; also that the advantages of simultaneous melting and refining include low first cost of equipment, lower slag production, few repairs, low operating cost, and a better product.

One way of lowering costs without increasing production is that adopted by Inspiration Consolidated, which cut per-pound cost of copper produced from 11.3c. in 1929 to 9.67c. in 1930 by treating higher-grade ore, shutting down the flotation plant, and improving the metallurgical work. United Verde Extension adopted flotation prior to smelting to remove excess gangue from low-grade sulphides, thereby reducing the amount of barren flux needed in the furnaces. Calumet & Arizona, prior to its merger with Phelps Dodge, improved its costs by replacing six 12-ft. vertical converters with three larger horizontal units, and adding four roasters to supply gas to the acid plant, thus releasing other roasters for metallurgical work. By reason of its acid contracts, this smelter has remained in service after the merger, whereas the Copper Queen plant, lacking such contracts, has been shut down. A new ore-bedding system, of simpler construction than the usual type and designed to operate at decreased costs and to improve metallurgical efficiency, was unable to achieve these results at the latter smelter, first because of intermittent operation and finally because of shutting down.

Modernizing of certain equipment and methods lowered costs and increased safety at International Smelting Company's Tooele, Utah, plant. A new drossing unit consisting of four 60-ton and two 120-ton kettles, which replaced four 30-ton kettles, cut operating costs considerably by increasing the lead-storage capacity. Further saving and safety from theft was effected by casting the lead in 4-ton blocks, instead of 90-lb. bars, and handling the blocks between mold and car by overhead crane. New electric monorail cranes were adopted for transporting lead bullion from furnaces to drossing plant. Changing the method of returning the heavy dross to the furnaces saved considerable labor. These changes collectively resulted in materially lower costs, which, however, it is impossible to specify with accuracy.

Savings by improved materials-handling methods and equipment have also been effected at the Bunker Hill smelter. The advantages derived from installing a tubular vibrator conveyor are mentioned elsewhere on this page in discussing dust recovery. Another cost-cutting innovation at this plant has been the Newnam pig-lead handling device, which has reduced the cost of molding and handling pig lead to one-third of the former figure. It was put in commission in March, 1930, before which date a hand-propelled circular casting wheel was used from which the pigs were removed by hand and trucked into the cars by hand.

Reduction to be made in operating costs by dust collection may be considerable where dusty conditions interfere with operation or affect the condition of equipment. If the dust collected is itself of value, the profit earned by the installation will fluctuate with this market value. Dust loss in moving pre-roasted material from the sintering machine at the previously mentioned Bunker Hill smelter was notably reduced by the

installation, in 1929, of the tubular vibrator conveyor referred to. The upkeep cost of this equipment has been only a fraction of that necessary to maintain other forms of mechanical steel conveyors. Lead recovery since it was installed has been increased three-quarters of 1 per cent, lead output being 70,000 to 90,000 tons a year.

Improvement in the means used for collecting dust in treating quicksilver ores has resulted in almost complete elimination of dust, with consequent reduction of costs. This illustrates the advantage to be obtained by devoting modern metallurgical skill to a previously neglected ore. A dust-collecting system installed at the plant of H. Kramer & Company, secondary smelters of Chicago, in sixteen months of operation recovered 3,400 lb. of dust per furnace per 24-hour operating day. As the market value of the recovered oxide increases, the equipment is expected to pay for itself and then begin to show a profit.

Utilization of smelter gases for making acid depends primarily on the existence of a market for the acid, with the possibility of suits for damages caused by smelter fume as a secondary factor. A classic example is the Tennessee Copper Company, which, compelled by court to build an acid plant, found in it a major source of profit. Plants recently erected include that of the St. Joseph Lead Company, at Josephtown, Pa., and the $10,000,000 plant of Consolidated Mining & Smelting, at Trail, B. C. In a 500-ton concentrator built at Rouyn, Que., the Aldermac Mines will recover sulphur from pyrite concentrate by the new Freeman process, and will sell it to the paper industry. Cost of handling large tonnages of fuel, fluxes, furnace feed, and drosses at Port Pirie lead smelter, in Australia, has been reduced by installing an elaborate telpher system; congestion and rehandling have been eliminated, dusting has decreased, and ventilation thereby improved, thus lessening the chance of lead poisoning.

Power generation frequently offers opportunity for reducing costs, especially where rates for purchased power are high. The Christmas Copper Company, Arizona, built a diesel plant in 1929, which that November gave a cost of $0.008399 per kilowatt-hour, excluding insurance, depreciation, interest and taxes. Even with the latter added, the cost would have been less than that of locally purchased power.

To overcome the handicap of dear power (1.5d. per kilowatt-hour, produced by burning wood under boilers or by gas engines running on producer gas) in the Kalgoorlie district, Western Australia, a 3,600-hp., crude-oil, diesel-engine power plant was built by the Lake View & Star. With oil at £10 per ton at the plant, this installation was expected to give an annual saving of £23,000. In the event of oil shortage, the engines can be run on producer gas. The new Wiluna Gold operations, at Meekatharra, 300 miles north of Kalgoorlie, will use electricity for power wherever possible. For this purpose, 540-hp. diesel engines will be employed to drive 450-kva. alternators. At Broken Hill, also in Australia, a central power plant of six 3,000-hp. diesel engines has recently been completed. It will eliminate individual coal-burning plants at three properties. In the United States, two new up-to-date steam-driven power plants, at Calumet & Arizona's mines and at Calumet & Hecla's Ahmeek mill, respectively, were placed in commission within the last eighteen months. Equipped to produce power at lower cost than that of purchased power, they have measured up to expectations, prevailing conditions considered.

Sulphur mining by the Frasch process requires large quantities of superheated water, as well as steam for power purposes. Freeport Sulphur at first burned oil under its twelve 700-hp. boilers; but, on substituting natural gas, found the latter cleaner and less troublesome, and with it raised the efficiency of the plant to 80 per cent. Texas Gulf Sulphur has had similar experience.

Waste heat, when utilized, is money saved. Its origin varies—diesel exhaust gases, metallurgical furnaces and kilns. If large units are available, low-pressure steam up to a few pounds' pressure can be produced in special boilers and used for miscellaneous purposes,

such as heating, drying, distilling, and the like, obviating the consumption of fresh fuel. Likewise, high-pressure steam can be made for power generation.

In cold climates, expenditure of money for insulating buildings properly will soon pay for itself in lowered cost of heating. In mills where grinding is being done, the heat thrown off in grinding may be enough to heat the building sufficiently, even in cold regions in midwinter, if the structure has been insulated against loss of heat. An example is the Teck Hughes mill, at Kirkland Lake, Ont.

Lubrication is often faulty and therefore offers a fertile field for cost cutting. By improving it in a mill sufficiently to reduce the frictional horsepower 10 per cent, the saving will usually be sufficient to pay for correct and adequate lubricant. Most large companies today regard lubrication seriously, and some are doing excellent work in reducing its cost. Economies effected were told at length in "Mine, Shop, and Plant," in a former issue. One case cited was that of a concentrator handling 2,200 tons of ore a day, which cut its lubrication bill from $7,000 to $8,000 per year to $2,700, simply by more efficient lubrication. Reduction in maintenance expense, through better lubrication, made the actual saving much larger.

Substitution of synchronous motors for the induction type for driving purposes in the field once largely dominated by the latter is held to possess various advantages. Definite savings result, which, however, are determined by several factors that differ in every instance. The foremost reason for considering the synchronous motor, according to R. S. Sage, in a recent letter, was its ability to send into the lines to which it is connected a certain amount of exciting kilovolt-amperes required by induction motors operating on the same lines, to raise the power factor of those lines, and to reduce the load upon lines, switches, transformers, and generators. The saving is due primarily to obviating the necessity for additional investment in this equipment. A saving is also effected by reduction of current consumption in these parts of the system. In many operations, a saving also results from the higher operating efficiency of the synchronous motor, though not always. When power is purchased, the application of synchronous motors may be accompanied by a percentage reduction in power rate, depending on local conditions.

A form of waste frequently overlooked is that of using needlessly too big a motor for a given job, as a 25-hp. motor driving a 5-hp. fan.

Eliminating a nuisance may give returns in greater earnings. Dust removal has already been discussed. Improper vibration of machinery may often be cured by proper balancing. If the vibration be unavoidable, though undesirable, its effect can in instances be lessened by mounting the machine on cork, or rubber or lead. Corrosion and abrasion may also be classed as nuisances. The difficulties caused by the former, and their correction, with resulting savings by using certain alloys, were dealt with at considerable length in the series of articles entitled "Mine, Shop and Plant," published in this magazine during 1929. One illuminating example is that of a copper company which protected its pumps against quick destruction from highly corrosive mine waters by bronze-fitting the pumps and using porcelain for certain parts, at an additional cost of about 7 per cent over that of the standard bronze-fitted pump. This was a worthwhile expenditure. Abrasion resistance of one variety of crepe rubber is so much greater than that of cast iron that, when this rubber was used in one installation for lining launders, the annual consumption cost per square foot with interest at 5 per cent was 8.5c., compared with $1.08 for cast iron.

Welding and cutting, whether by gas or electricity, have proved themselves great money savers. Their advantages in shop work, in making quick emergency repairs, in lengthening the life of many varieties of equipment by permitting the rebuilding of worn surfaces, and in simplifying structural design, are too numerous to mention. One example of rebuilding worn parts will suffice as typical: Cheek plates on rolls of various sizes have been built up so that they were as good as new, at a cost of $1.50 to $2, whereas formerly new castings were required at a cost of $16 to $20.

In closing, the fact should be emphasized that standardization of technical practice and equipment makes saving and cost reduction possible in many ways. Standardization reduces warehouse stocks and inventories, makes warehousing simpler, and permits purchasing of fewer items and those in larger quantity, thereby affording a price advantage. Moreover, the careful study of the quality of materials and supplies, before and after purchasing, permits wiser, more economical buying, and the avoidance of considerable waste.

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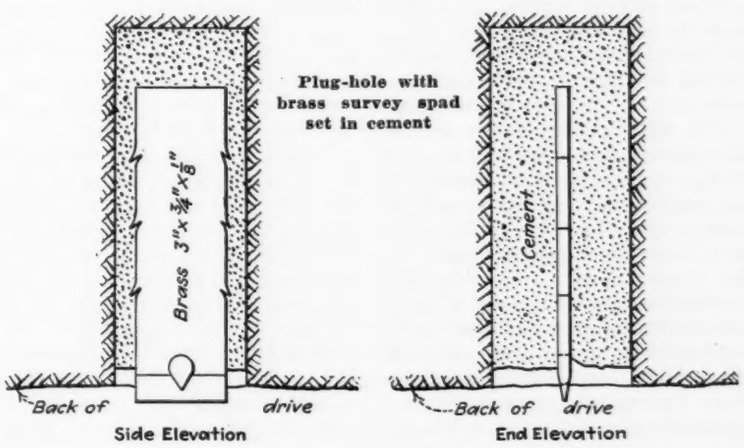
Permanently Fixing Underground Survey Stations

WOODEN PLUGS, to hold a brass survey spad and set in a hole in the back or roof of a drive, are unsatisfactory. A rail dog driven up with the plug into the hole aids by its rusting and consequent swelling, but even then, with a sufficient and continued drop in humidity, the plugs will loosen and fall out, writes A. B. Black, chief surveyor, Broken Hill South, Ltd., Australia.

Many a surveyor has experienced the loss of survey stations thus. Moreover, a wooden plug is a temptation to an electrician or pipe fitter in a hurry to do a temporary job. The result of such losses means repetition of survey work, if not complete transference of the survey from the surface of another level.

To avoid these difficulties, a brass mark set in neat portland cement, as shown in the accompanying sketch, is used at the Broken Hill South mine for all permanent stations. The cement, mixed fairly dry and well rammed, sets sufficiently in fifteen minutes, so that little time is lost. The resulting survey station can be affected only by a fall of ground. For placing bench marks in a horizontal hole in the side of the drive a similar method is employed.



Asbestos Milling in Quebec

W. A. RuKeyser

THE past decade has witnessed the completion of three new steel and brick mills at Thetford—the King and Beaver, of Asbestos Corporation, and the Johnson. One, The Nicolet, Danville district, is of timber. Johns-Manville erected a large new plant, details of which are not available. At the Nicolet the short-fiber character of the ore permits extreme simplification of flowsheet. The three new mills in Thetford can therefore best be described as more typical of present-day technique in Canada.

Asbestos milling in general involves recovering from the rock as much as possible of the fiber, of maximum average length. Some grades are most acceptable to United States manufacturers if in a well-opened state; other markets prefer a minimum of fiberization, the object being to produce material as "crudey" as possible.

The fibrous nature of the chrysotile and its greater tensile strength are the outstanding differences between it and the inclosing serpentine gangue. An increasing recognition of this latter difference may effect a considerable reduction in power consumption, the avoidance of fiberizing the asbestos in contact with the rock mass except for the shortest of grades, and reduced necessity to separate the fiber from the gangue by air suction. Fiber length will be preserved, first cost of milling plants will be less, cleaning steps will be reduced, with simplification of the flowsheet and reduction of maintenance costs. The change permits the extraction of the fiber in an extremely "crudey" state, the extent of opening being under control during subsequent fiberization of the asbestos, in the absence of gangue material. Combinations of the two principles will probably also find adaptation. The crudes and longer grades can be extracted first by utilization of a process based on tensile strength, to be followed by fiberization of the shorter grades and their separation by the air suction, as at present.

Essentially, the concentration of asbestos by milling consists in two or three stages of coarse crushing, followed by drying, screening, and recrushing in stages, each step being followed by screening and air suction to effect separation of fiber from gangue; fiber collection, removing adhering dust and rock particles by re-screening with or without application of air suction; grading; additional re-cleaning of each graded product, with or without air suction. This process, typical of practice in the newest Canadian mills, differs little in principle from that used during the 'nineties, but the mills built during the past decade appear on first sight to be radically different, externally and internally, from their predecessors. Formerly, the buildings were of local timber. The maze of machinery, air piping, chutes, crossovers, bypasses, and the like made the determination of flowsheet by a newcomer a lengthy matter. Dust hampered visibility, militated against the workers' health, and added considerably to the difficulty of maintenance, repairs, and control. Technical procedure was seldom predetermined; it too often grew according to the dictates of each manager. Flowsheets were subject to continual alteration because of changing market demands and to a lack of grade standardization. All this has now been changed. Centralization of properties under markedly fewer owners and operators; reduction in the number of grades required by a market that, in turn, is more stabilized; obsolescence or destruction by fire of the old, wooden structures; an influx of technical personnel and operating ideas from other fields—all these factors have favored buildings in brick and steel and a simplification of flowsheet that characterizes the King, the Beaver, and particularly the Johnson plants.

Relative efficiency is indeterminable. Exact percentage content of mill feed and tailing by chemical analysis is impossible. A physical determination to check mill results must be approximate, and largely dependent on the personal equation. This, perhaps, is a major reason why flowsheets of mills operating on contiguous orebodies differ so widely. No yardstick is available to determine absolute results and to explain differences of personal opinion. Results of mill runs are usually based on weight of rock fed to the mill and production of fiber resulting. Thus, in Canada—where, because of proximity to the United States, the short grades are salable and can be included in the fiber output from the mills—the asbestos content of the rock in the ground as well as the extraction will be given as 5 to 6 per cent. However, should the calculations be based only on output through paper stock (as was the case in Russia in 1929), the apparent yield would be about half. Readiness to accept operating figures as absolute may lead to erroneous conclusions.

Furthermore, deposits vary so greatly—in hardness of rock, toughness of fiber, asbestos content, for example—that a flowsheet applicable to one deposit might be unsuited to another, even though located in the same district. Modifications of practice often indicate individual taste and judgment rather than scientific conclusion based on comparative data. In the last decade, however, with the establishment of laboratory facilities and a better interchange of technical information, flowsheets have become more and more standardized. Fig. 1, which is a reproduction of the flowsheet of Black Lake Asbestos & Chrome mill, illustrates the complexity of mills in Quebec before the War. Fig. 2, of the mill of Asbestos Mines, Ltd., working on slip fiber and re-equipped in 1920, shows the beginning of the definite trend toward (1) the replacement of cyclones by jumbos; (2) two-unit layout; (3) screen removal of fines before crushing; (4) simplification—indicative of present practice in the newer and larger plants.

Fig. 3 represents a combination of newer features with some of the best features of former practice, by which maximum extraction of fiber, well opened, and with a maximum of cleanliness, is desired. It may be likened to the practice in one of the older mills in the Thetford district, still considered

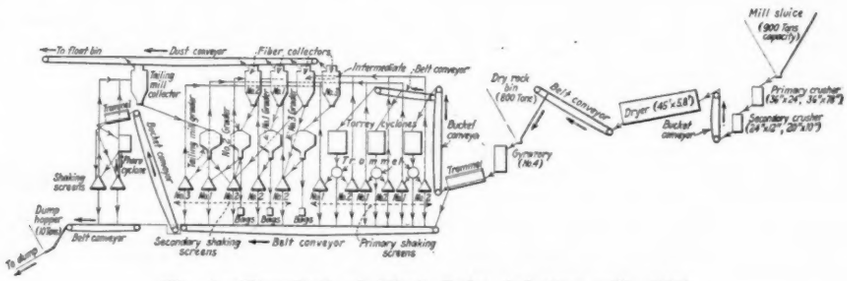


Fig. 1—Flowsheet of Black Lake Asbestos mill, 1920

one of the best, by users of the fiber and by operators. Cyclones, not shown in the flowsheet, are still used for grinding tailings. Grading is done on flat shaking screens, not as another cleaning stage in the revolving trommels I have shown as following these screens in the flowsheet. This plan indicates a maximum of refinement of flow, with almost complete extraction, openness of fiber, cleanliness, and flexibility for change or control of operations.

Fig. 4 is illustrative of crushing-plant practice at the newest mill, the Johnson. Fig. 5 is a flowsheet typical of modern Canadian technique. It has been compiled from information, obtained during visits to various plants, from published photographs and data. It represents the latest trend in Quebec toward simplification and standardization, made possible by agreement among world operators favoring reduction in the number of grades, and standardization in the tests of grades produced; also by the removal of the urge to extract the last particle of extremely short fiber from the rock—a factor that involves complication of flow, additional cleaning stages, usually more attrition to the longer grades, and operating costs out of proportion to additional recovery.

My opinion, based on experience here and abroad, is that the loss of a small amount of shorts in the tailing is preferable to an attempt to secure complete extraction, with some breaking down of longer fibers, complication in flow, additional power for fine grinding, and recleaning. In Canada, particularly, if a heavy demand for the longer grades follows a higher ratio of shorts to long fiber in the mined rock, a superabundance of short grades will result. If demand for the longer grades is relatively less than that for the shorts (as at present), more than sufficient of the lower grades will be produced during minimum mill operations, involving storing the longer grades, which means capital expense. A near-by market exists for shorts and waste grades, and this fact constitutes a major difference between the economic problems in Canada with, for example, those in the Urals.

The coarse-crushing plants in Quebec utilize almost every known type of primary breaker. No standardization is discernible. Primary crushers are of the jaw and gyratory types; I prefer the former in asbestos work. Secondary units consist of jaws, gyratories, rolls, Symons cones, or hammer mills; tertiary units, of gyratories, Symons cones, or in one case disks, but mostly hammer mills of the Williams type or local modifications. Dryers are of the horizontal, rotary, direct-heat type, with the rock flowing concurrent to the gases, so that the hottest flame will strike the wettest ore and thus prevent "scorching" or partial dehydration of the fiber, which may produce brittleness. They are of the vertical, tower, stationary, Edison type, patented in Canada by Asbestos Corporation with application confined to the properties of that company. The tower dryer as there applied consists of a stack about 50 ft. high by 7 ft. square in cross-section, fitted with baffles or grid-bars of special design. The flow of the rock is counter-current to the flow of the gases arising from the fire boxes at the bottom. The ore is elevated by bucket to the top. These features constitute two possible disadvantages. The stack dryer has no moving parts, but the reliability of the rotary unit, ease of inspection and repair, and low power requirements, indicate advantages. Much power is required to elevate the mill feed over 50 ft. Furthermore, the ball-mill action of the rotary dryer is desirable, a considerable amount of fiber being liberated and opened during the process and while the rock is still moist. Thus the power required for this type of dryer can hardly be said only to effect passage of the ore through the machine. It is the standard type of dryer in every plant except that of Asbestos Corporation. Although less efficient thermally than a unit of the combined direct-indirect heat type, or the bricked-in variant, the ease of repair dictates its use. The shells have not been covered to minimize radiation.

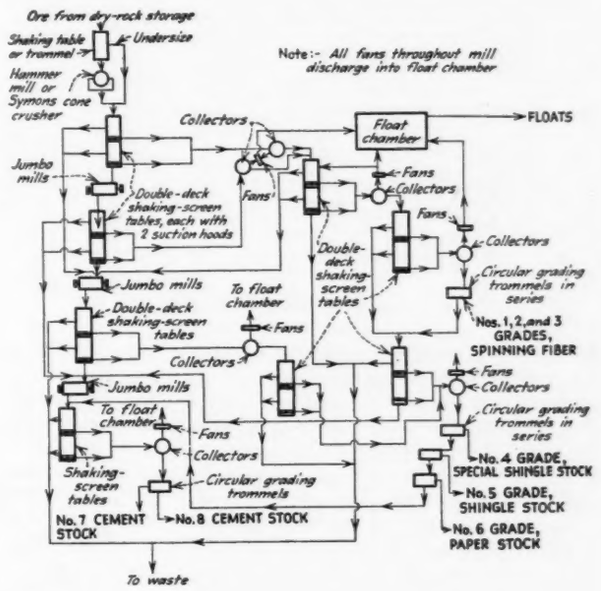


Fig. 3—Generalized flowsheet of Canadian practice

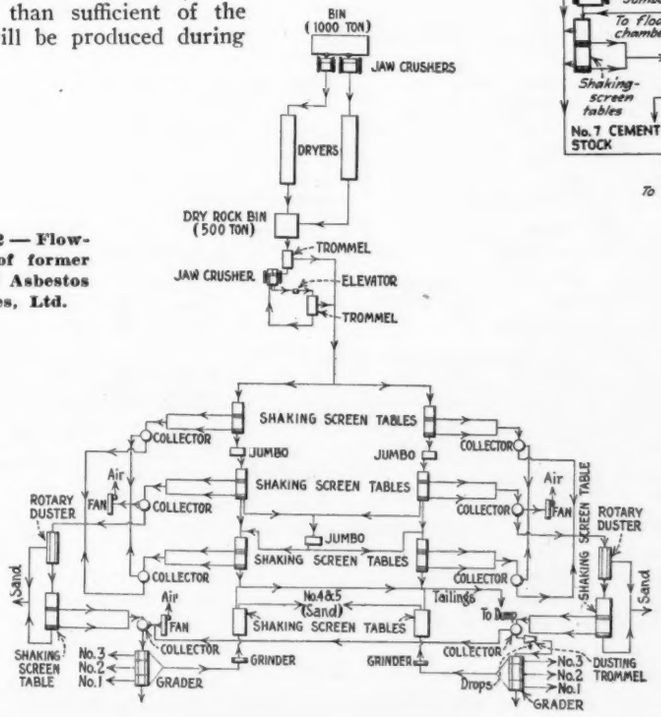


Fig. 2 — Flowsheet of former mill of Asbestos Mines, Ltd.

At the Johnson mill is the first application of pulverized coal firing, which I first included in designs for Russia in 1928: the drying operation is usually performed on rock reduced to between 2 and 2½ in., after secondary or tertiary crushing.

In all the newer plants in Canada are large dry-rock storages, with few wet-rock bins. The hygroscopic nature of the ore, the surface moisture, snow, and ice found in winter in Quebec, prevent the use of bins ahead of the drying

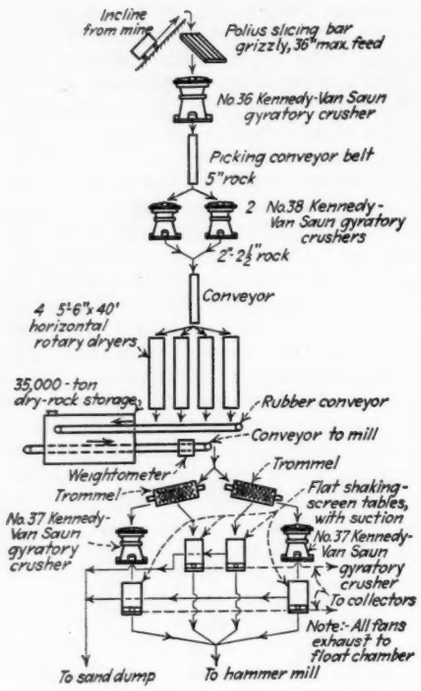


Fig. 4—Crushing plant flowsheet, new mill of Johnson Asbestos Company, 1930

plant. Receiving hoppers for primary crushers are common, without surge bins following. Provision of large storage of ore ahead of the primary crusher, to be reclaimed by power shovel during the winter months to supplement or replace winter mining, has not to my knowledge been tried in Canada. Provision for this has been made in Russia.

Dry-rock storage is usually of 25,000 to 30,000 tons' capacity. At East Broughton a recently completed storage has 150,000 tons' capacity, and apparently the company intends to avoid winter mining in open cuts and intends then to draw entirely on this storage. A concrete reclaiming tunnel equipped with chutes on 5-ft. centers, and conveyor belt running to the mill proper, is constructed on or below the ground. This tunnel is banked on the sides with waste rock or sand up to the angle of repose, forming the bottom for live-rock storage. A cribwork of ties or a foundation of concrete supports the sides of the storage bin and the superstructure carrying the incoming conveyor and tripping mechanism. Fines and coarse rock are best stored separtely, so that a regular mill feed will result by proper drawing. The bin acts as a storage and source of feed, and permits the "seasoning" of the dried rock to a proper moisture content and to uniform characteristics.

After drying, the rock is usually elevated to the mill by means of belt conveyor. It passes over vibratory or flat shaking screens, with or without suction, and the oversize goes to the first reduction unit, of gyratory crushers, rolls, or, in one mill, Symons disk machines; but more frequently hammer crushers of the Williams type or a local modification, or jumbos—rigid-hammer crushers of local manufacture. In the application of Williams crushers in Thetford, the usual bars have been replaced by a hemispherical plate with a longitudinal groove, permitting prompt discharge and avoiding undue attrition of the fiber. The material then flows to flat shaking screens (250 to 450 r.p.m.; slope, about 1:12; 2 hp.) to separate the sand (minus 8-, 10-, or 12-mesh undersize) and to bed the rock and fiber, making the latter amenable to the action of the aspirators. These are sheet-metal hoods running the width of the table, usually 5 ft., and having a 4-in. opening through which the fiber is sucked. Hoods, which terminate in a circular pipe of from 12 to 20 in. diameter, which leads direct to collectors, can be raised or lowered. The collectors, in every modern installation, operate under 1½- to 2-in. water suction. Fiber does not pass through the fans, and the load is dropped by reason of reduction in velocity of the air carrying the fiber on entering the collector. Fiber and air from the suction hoods enter at the side of the collector. The air, after dropping its load, passes out at the top, to be exhausted by the fans into a large dust chamber, usually larger than the mill itself, of sufficient size to permit reduction in air velocity so that the remaining dust or "floats" (a salable product) is precipitated. The fans in all modern mills at Thetford are of the Keith multiple-blade type and made by Sheldon's Ltd., of Galt, Ont. They are usually direct-connected, two to one motor, run at 750 to 900 r.p.m. and handle from 25,000 to 40,000 cu.ft. of air per minute, at velocities up to 100 ft. per sec.

The collector, usually of vertical type, the cylindrical section of which varies in general practice from 5 to 7 ft. high and from 5 to 7½ ft. diameter, discharges intermittently by gravity at the bottom through a canvas trap closed by suction and opened against leather springs by the accumulated weight of the fiber behind it. This fiber falls on flat shaking screens for cleaning unopened particles, rock, dust, and sand. The tables may or may not be equipped with suction. If so, the purpose is primarily the elevation and transportation of the fiber, more easily effected by air than by other means. The asbestos may then be recleaned on screens or graded. In the more modern mills the graders are circular trommels, 3 to 5 ft. in diameter, usually 5 ft. long, of two general types. The first, with a stationary screen, is equipped with an inner shaft fitted with wooden arms, bearing paddles. These rotate at 600 to 800 r.p.m. The fiber is forced through the screening by the paddles. In the other type, rotary screens of the same dimensions, which revolve clockwise at about 50 r.p.m., have riding rings mounted on light rollers at each end, are gear or sprocket driven, and have a central shaft, turning counter-clockwise, also equipped with light wooden paddles to keep the fiber agitated. Speed of rotation of the paddles is from 180 to 250 r.p.m. In either case the trommels are fitted with woven-wire cloth. Each, in what I consider good practice, makes only one

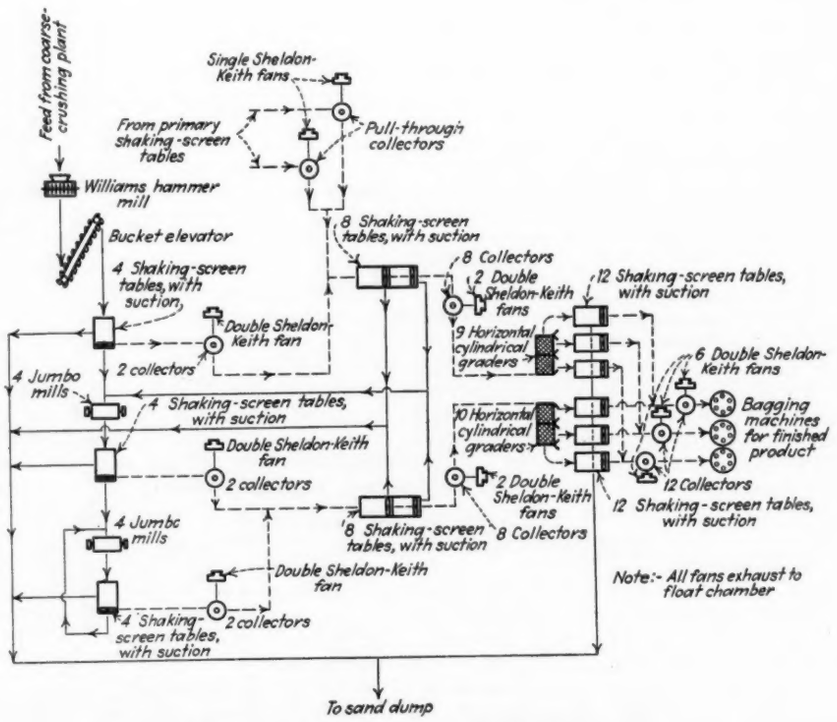
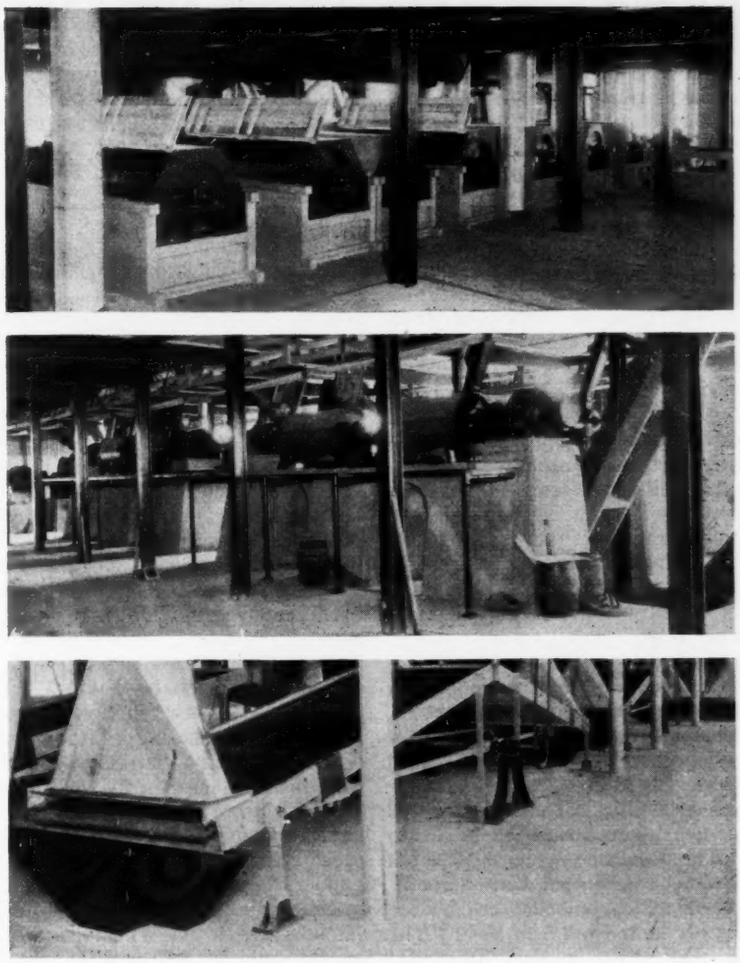


Fig. 5—Typical flowsheet of Canadian practice

finished grade. In this system of grading the longest fiber is taken off the first screen with the largest opening as oversize. All the shorter grades, with dust or grit, pass through the openings to the next trommel, where the second longest grade is taken off as oversize. However, in the latest mill, in Thetford, the trommels, which are stationary, are equipped with two openings of screen cloth, thus making two undersize grades and one oversize. The oversize from the primary series of shaking-screen tables goes for further crushing into a series of jumbos (capacity 25 to 30 tons per hour, 600 to 1,000 r.p.m., 50 hp.), and the product from these is delivered to a second series of shaking screens, also equipped with suction, from which fiber is lifted to another set of collectors. This process is again repeated, with the oversize from the second tables going to a second series of jumbos and to a third set of tables, from which the shortest fiber is lifted. All grades of fibers have thus been primarily lifted to about two or three sets of collectors. Therefore, if this fiber after cleaning is made to fall on two series of graders, at least six primary grades can be obtained. Should more be required, the products can be mixed. Each may be further cleaned by vibrating screens, which find their best application here, but if used in the primary circuit for separating heavy sand, these are best followed by flat shaking screens, to bed the fiber for separation by air; or by flat shaking tables, which may drop the load by gravity to packing bins or be equipped to air-suck to collectors, from which the fiber falls into a bin.



Top—Trommel section of asbestos mill. Middle—Jumbo mill section. Bottom—Shaking-screen tables. Photos courtesy Canadian Asbestos Company.

At the King mill, of two units with a combined capacity of 200 tons per hour, the primary jaw crushers, 24x36 in., are fed from a hopper through a vertical grizzly, each bar of which is actuated by air plunger. The discharge (4 to 5 in.) falls on conveyor belts, from which wood, steel, and crude are picked. The secondary crusher in this plant consists of corrugated rolls, which seemed to me to do little appreciable work on the ore. As soon as conditions permit, I was told, these rolls would be replaced by a Symons cone crusher.

The rock is dried in three stack units of the type described. Then the rock is stored in a bin, also described, of 25,000 tons' capacity, and later conveyed by belt to the mill control bin. The mill is of four floors, as compared with six at the Beaver and Johnson, permitting saving in headroom and avoiding cost of elevating ore and fiber, and, consequently, lower first cost. From personal observation, as well as by conversation with Captain Ross, mines manager of Asbestos Corporation, I learned that, at the Beaver at least, only four of the six floors are in use. An apparent waste of floor space is involved, at a sacrifice to costly headroom.

The King mill contains (1) screens with suction; (2) hammer mill; (3) screens with suction; (4) cyclone (the only modern mill employing this type of machine) of Torrey design, again followed by (5) screens with suction; (6) jumbos followed by screens and suction, and (7) jumbos for tailing, also followed by screens and suction. Fiber from the collectors falls on rotary graders and then on cleaning screens. Fans exhaust into a float chamber.

The King is the only mill using vibrating screens, of the Hum-mer type, for removing sand—suction being applied at the discharge in an ingenious manner. They are followed by flat shaking screens for an absolute separation of fiber from gangue by suction. Screens are of woven wire, of 8, 10, or 12 mesh, except the initial ones, which have $\frac{1}{8}$-in. punched plate. All sand goes to dump. Oversize of cleaning tables is recrushed in jumbos.

The Beaver mill—a two-unit plant of which only one unit of 100 tons' per hour capacity is installed—has a 36x40-in. primary jaw crusher, fed from electrically dumped cars. This is followed by a set of 50-in. corrugated rolls (also to be replaced by a Symons cone), after which the rock is further reduced by a King-type hammer crusher; thence by conveyor belt to three hand-fired stack dryers, 7x7x50 in. A 25,000-ton storage bin is provided for dry rock, and an automatic weighing machine operates on the conveyor to the mill. Incoming ore passes over a Niagara sizing screen, then to crushers, King hammer mill, Williams hammer mill, and two stages of jumbos. After each crushing, fiber is lifted from flat shaking screens by Sheldon fans, in pairs, direct-driven by one motor, and caught in vertical-type collectors now replacing the non-orthodox type at first installed. The fiber from the collectors is taken by conveyor to the rotary grading screens. After grading, it is recleaned and bagged.

The Bell mill, which has a capacity of 75 tons of rock per hour, has a modernized flowsheet, the origin of which dates back to the decade before the War. The work of this mill is equal to performance elsewhere in the district. Twin crusher chutes feed two 36x24-in. jaw crushers of Canadian I-R manufacture. These break the rock to 5 to 6 in., and discharge it on a 36-in. conveyor picking belt. This discharges on a return belt, thus upturning the rock for better visibility

and the uncoverage of crude and débris.

The ore is dried in two coke-fired, direct-heat horizontal rotary units, 5½ ft. diameter by 40 ft. long. After drying, it is transported by belt conveyor to a rotary screen, the oversize from which goes to a Symons cone. Undersize from screen and product from the Symons goes to a 6,000-ton dry-rock concrete bin storage, 225 ft. long. The mill proper is in two units, the first crushers of which are Williams hammer mills. Tailing regrinders are still of the cyclone type, a carry-over from former practice. Slow-speed, flat, shaking screens (250 r.p.m., as opposed to the 400-500 r.p.m. of the Beaver and Johnson type of screen) remove sand and provide a bedding of fiber for removal by suction. Grading and cleaning in this mill are effected on flat shaking screens. Tailing is removed to a 1,000-ton storage bin and drawn to the dump in train. Distance precludes the use of inclined conveyors. Extraction is exceptionally high, reported more than 8 per cent.

In the Nicolet mill, operating primarily on rock reported as containing little fiber longer than good shingle stock, the Symons cone crusher finds particularly excellent adaptation. This mill employs a 28x36-in. Traylor primary jaw crusher with a capacity above 100 tons per hour, from steam-shovel size to 5-in. The secondary crusher is a 4-ft. Symons cone, fitted with a corrugated bowl, which will also crush over 100 tons per hour from 5 to 1½ in. The rock is then dried in two horizontal rotary units, 5¼x40 ft. long, driven by two 40-hp. induction motors. Draft is induced by a Sheldon fan (No. 8) driven by a 10-hp. motor. Dryer capacity under adverse weather conditions is 50 tons of rock per hour. The two dryers, as well as the mill equipment, constitute only one-half of the proposed two-unit installation. The third crushing is also by Symons, followed by two stages of jumbos in groups of three and two, respectively, followed by five shaking-screen tables each fitted with two hoods. The fiber is sucked to collectors, cleaned on flat shaking screens, and graded in rotary machines. A little short spinning fiber constitutes the longest grade produced, most of the output being shingle, paper, and cement stocks.

The Johnson mill, completed in 1930, is the latest to be erected in the district. Generally speaking, its design follows the major features of the Beaver, but with correction of the mistakes alleged to have been made in the original design of that mill. The mill is designed to operate in two units (only one at present installed), each of a capacity of 100 tons of rock per hour. Fig. 4, the flowsheet of the crushing plant of this mill, shows the major features. A concrete bypass permits direct passage from dryers to mill.

In the mill proper, of six stories, the crushers are on the ground floor. Elevators lift the material to the primary set of shaking screens on the second floor. Cleaning screens are on the third, graders on the fourth, collectors on the fifth, and fans on the sixth. One may wonder why the fans and collectors are not arranged on one floor, and all screens also on one floor, thus possibly reducing one-third of the mill height, with attendant saving in first cost and operating expense.

In all there are 36 collectors; 13 double fans; 2 single fans; 56 shaking screens; 8 jumbos, each driven directly through magnetic clutch by a 50-hp. motor; 19 graders, stationary screening surface, inside paddles rotating at 780 r.p.m. The two jumbo stages follow, first, a trommel, the oversize of which goes to two No. 37 Kennedy-Van Saun gyratory crushers, followed by a Williams hammer mill direct-connected to a 125-hp. motor. Screens are provided with suction between and ahead of all crushing stages.

On entering the mill the ore, automatically weighed, is screened in trommels, undersize from two of which falls to a pair of flat shaking screens, equipped with air suction. Oversize from the trommels goes to a pair of No. 37 Kennedy-Van Saun gyratories, with discharge to the two flat screens. Oversize from these goes to the Williams hammer mill. Oversize from each intermediate screening operation (undersize sand to waste conveyor, fiber to collectors) goes to the two successive jumbo stages. The undersize from the last screen is delivered to the sand dump. I believe the oversize is to be put in closed circuit with the last crushing stage. The fiber from the collectors falls upon flat cleaning screens, thence goes to high-speed graders, and thence to flat shaking screens for the cleaning of each grade separately. The fiber is mixed in screw conveyors—a questionable practice in my mind; a disintegration of the fiber may result.

The total connected horsepower of the Johnson mill is given as 3,500 for the one unit, with 1,300 required for the additional one when installed. This would make a total of 4,800 for a 20-hr. capacity of 4,000 tons. Asbestos Corporation employs a total in all of 16,000 hp. in mines and mills, its six mills having a capacity in excess of 500 tons per hour, or 20,000 tons per day of 20 hr. The average kilowatt-hours per ton of rock *mined and milled* for the entire district is a trifle under 12. This would average about 16 hp.-hr. for each ton, or, at 0.7 power factor, nearly 1 hp. for each ton of rock mined and milled.

Before leaving the subject of technique in Canada I take this opportunity to suggest: (1) A separate flow for screened fines removed before each coarse-crushing stage, with separate dryer for fines; this would avoid undue attrition on already liberated fines by ball-mill action in the dryers, and also permit better temperature control for fines high in asbestos content; (2) separate storage of fines, to prevent attrition by the 2½-in. rock in drawing down in the large bins; (3) further experimentation with the Newhouse crusher for secondary and tertiary crushing (employing as it does the straight-squeeze-crushing and immediate discharge ideal for asbestos work); (4) the general adoption of pulverized-coal or oil-fired dryers, insuring better temperature control, if not added economy; (5) bypassing ore around dryers where weather permits; also the provision of shuttle conveyors to feed dryer surge bins; (6) more closed circuits, whereby coarse crushing will liberate a greater proportion of the fiber; (7) elimination of waste rock, by picking from slow-speed belts; and elimination of waste and below-grade rock after secondary crushing, by selective screening, as will be explained in my article dealing with milling in Russia, where 60 per cent of crusher plant feed is eliminated before fine grinding, as waste; (8) mechanical cobbing of long grades after rough sorting only by power shovels in the mines, followed by the usual methods for extraction of the shorts; (9) better utilization of floor space, with attendant reductions in head room, saving in power; (10) use of vibrating screens for cleaning graded products; (11) lighter loading of shaking-screen tables, which from my experience and tests indicate cleaner fiber and possible elimination of one or more cleaning stages.

Can a Mining Method Be Patented?

Mr. Eaton Comments on Mr. Huttl's Recent Article

To the Editor:

I have read with much interest the article by Mr. J. B. Huttl on the "Elsing Sublevel Shrinkage Method of Stoping."[1] The method as described is an ingenious one, and has followed in many respects the same lines as those followed by other engineers in their attempts to reduce the amount of development required in sublevel stoping. There are, however, certain weaknesses in the method as described, which I will take up briefly later. One of the most interesting statements in regard to it is that "A patent has been granted."

Patents on mining methods are very difficult to enforce, and it is my understanding, in which I may be in error, that a valid patent can be granted only for two things:

1. A new idea, process, or device, or the application of a known idea, process, or device to a new use.

2. An improvement on a known idea, process, or device, through the use of which better results are obtained.

Publication of the description of a process or device, or its application, in a technical magazine, government publication, or the proceedings of a technical society, constitutes, I believe, adequate proof of public knowledge of the subject.

The sublevel method of mining has been in use since 1902, and many papers have been written describing its variations, of which the following may be cited as examples:

Peele's "Mining Engineers' Handbook," 2d Edition, p. 587; 1927.

"The Spies System of Mining," by S. R. Elliott, *Trans.* A.I.M.E., March, 1922.

"A Novel Method of Sublevel Stoping," by R. B. Wortley. *Eng. & Min. Jour.*, Vol. 126, No. 22, 1928, p. 867.

"Mining Soft Hematite by Open Stopes at Mine No. 1, Menominee Range, Mich.," by Lucien Eaton. Information Circular 6180, U. S. Bureau of Mines, October, 1929.

"Mining Ore in Open Stopes in Central and Eastern United States," by Charles F. Jackson, Information Circular 6193, U. S. Bureau of Mines, November, 1929.

"Mining Methods of the Tennessee Copper Company, Ducktown, Tenn.," by C. H. McNaughton. Information Circular 6149, U. S. Bureau of Mines, June, 1929.

The new ideas claimed for the Elsing method appear to be:

1. An overhanging brow.
2. Large sublevels.
3. Ring-drilling.
4. The use of broken ore for support of the walls and of the working face.

In strong ground an overhanging brow has often been used in sublevel stoping. See Peele's "Mining Engineers' Handbook," p. 587, Fig. 196.

Sublevels as large as 12x12 ft. in cross-section as far as I know are new. A section 8x8 ft. is not new, however, and has been used for some time with scrapers to remove the broken ground. Unusually strong ground is necessary to a section as large as 12x12 ft., and the advantage of this size may well be questioned.

A patent was issued, I believe, for ring-drilling in tunnels, but whether or not it is valid I cannot say. Ring-drilling in sublevel stoping, however, has been common practice for ten years or more at the Spies mine, in Iron River, Mich., and at the Morris-Lloyd mine, in Ishpeming, Mich. The suggestion of using deep-hole drilling to increase the sublevel interval might work if all the holes were drilled upward, but ordinarily deep-hole drilling is not successful in down holes. The cost per foot of hole is also much higher than that of ordinary drilling. Diamond drilling may also be ruled out on account of its cost. Otherwise the logical proceeding would be to omit all sublevels and to drill holes parallel to the face for the full height of the stope.

The last and principal claim is support of the walls and working face by the broken ore. The broken ore affords some temporary support to the walls, as in ordinary shrinkage stoping, but, if this support is needed, there is always dilution, when the broken ore is drawn off, and the longer the drawing is delayed the greater the amount of dilution. In the Michigan Iron Country there is less dilution in sublevel stoping than in shrinkage stoping, and sublevel stopes can be successfully used, where shrinkage stopes would fail. There is a time element that enters into the question of failure of stope walls, and quick removal of the ore from the stope is advantageous. If the working face is carried nearly vertical very little ore is thrown beyond the second hopper, or mill hole, and, if waste falls beyond that point, little damage results.

It seems to me that the broken ore will give little, if any, support to the working face. If it is packed tightly against the face by the blast, the powder consumption will be high, although comminution may be improved. Even assuming support in this way, however, there is a difficulty inherent in the method, which has apparently been overlooked, and this is the difference between the angle of rest of broken ore and the angle of draw. When ore is broken in a blast or is dumped in a pile, it will assume an angle of rest of 35 deg. or less. When, however, the ore is loaded from the foot of the pile or is drawn from chutes this angle is steeper, and may be as much as 55 deg. Hence, in the Elsing method, if ore is drawn from the chutes near the face, more ore will be drawn from the lower part of the face and less from the upper part than will make room for the succeeding blast.

In sublevel stoping in strong ground it is customary to cut a "trail" or "bench" across the face on each sublevel, extending right and left from the central drift, and from this bench holes are drilled up and down for breaking the ore. Any irregularities in the mineralization along the footwall or hanging wall can be followed on any sublevel, working from this bench, and ore that might otherwise be lost is recovered. This is one of the advantages of sublevel stoping over shrinkage stoping and over the Elsing method. Another is that large chunks, falling freely through the stope, are partly broken up by the fall, and secondary blasting is thereby reduced. Because the ore is not allowed to accumulate in the stope, sublevel stoping may be used where the footwall is as flat as 40 deg., whereas the limit for shrinkage stopes is 50 deg. To these advantages may be added quick recovery of the ore after it is broken, preventing oxidation of sulphides and tying up of capital, and greater safety. The only disadvantage is the greater amount of development required.

The Elsing method retains most of the disadvantages of shrinkage stoping and also the one disadvantage of sublevel stoping—namely, higher development cost—and it retains only the improvement in safety.

Much could be written about pillar recovery, but I will merely call attention to the fact that the methods advocated have little that is new. Moreover, if the ore stands well enough without support to be safe as a floor pillar across the top of the stope, and if the walls above this floor pillar stand so well that the broken ore in the stope below will not be contaminated, when the floor pillar is shot down, then it is unnecessary to leave broken ore in the stope below for support of either the working face or the walls.

As far as economy is concerned in comparison with standard sublevel practice, it is necessary only to compare the estimated cost of the Elsing method with the actual results obtained by the Tennessee Copper Company. The estimated cost of the Elsing method is $0.653 per ton. At the Burra Burra mine (see U. S. Bureau of Mines Information Circular 6149) the stoping and blockholding costs for the year 1928 amounted to $0.332 per ton, including much of the stope development cost, and if all the mine development charges for the year be added, the total cost per ton delivered to the cars was only $0.561. The amount of development done that year was more than was required by the rate of production, and some of the ore mined came from older sections of the mine, where methods more expensive than sublevel stoping were being used.

LUCIEN EATON.

Boston, Mass.

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Mr. Elsing Elucidates

To the Editor:

In analysing Mr. Lucien Eaton's criticism of my sublevel shrinkage method, although he says it is ingenious, I find (1) that he intimates that the Patent Office should not have granted me a patent; (2) he states that there is a difficulty inherent in the method which has apparently been overlooked, and (3) he draws an unfavorable comparison of my cost with the cost of sublevel stoping at the Tennessee Copper Company's property.

In reply to the first contention, I am frank to say that I have combined three

[1] *Eng. & Min. Jour.*, Dec. 28, 1931. Any subscriber who wishes a reprint of this article may obtain it by making request to the Editorial Department.

well-known methods—namely, shrinkage, sublevel stoping, and ring-drilling—in a way that has never been done before. Mr. Eaton lists my claims as (1) an overhanging brow; (2) large sublevels; (3) ring-drilling, and (4) the use of broken ore for the support of the walls and of the working face.

I actually make only one claim, and that is the use of broken ore resting at its angle of repose as a support for the working face. This feature is distinctly new, and it was on this basis that the patent was granted.

The "inherent difficulty" of which he speaks is the "difference between the angle of repose of the broken ore and the angle of draw." This matter has not been overlooked. Any tendency of the broken ore to assume an angle as steep as 55 deg. is not a serious matter, because such a tendency can be quickly overcome in a number of ways. In the first place, the drawing of ore from chutes farther back from the working face will prevent the slope of the face of the broken ore from assuming such an angle. With improper drawing the slope of the ore might assume a steeper angle than the angle of repose. This, however, will continue only up to a certain point, when a surge will take place and the ore will then assume the angle of repose. It must be remembered that the condition of the face of broken ore can easily be observed from the several sublevels. The opening between the face of solid and broken ore will seldom be more than 5 or 6 ft.; and, if it should hang up, it can be readily broken down either by barring down from the sublevel or by placing a stick of powder on a blasting stick and blasting it in the proper place, causing the ore to assume its angle of repose. Under most conditions, proper drawing will make such steps unnecessary.

Suffice it to say that Mr. Eaton's criticism of my cost analysis is very unfair to me, simply because my cost includes items which are not included in his Tennessee Copper cost. My cost estimate shows each item. I included 8c. per ton for miscellaneous charges, and 3.5c. per ton for supervision. The Tennessee Copper cost statement shows both supervision and general underground expense, and it is inexplicable to me why Mr. Eaton has ignored these items in making his comparison.

In mining certain large orebodies I propose to break the ore by blasting in coyote sublevel drifts and raises, that will be parallel to the angle of repose of the broken ore. In this, the method is somewhat similar to the Alaska Juneau method, except that in my method the ground being worked will be supported by the broken ore resting at its angle of repose. Under proper operating conditions, I see no reason why exceedingly low costs cannot be obtained with my method.

I admit that sublevel stoping can be applied to slightly flatter orebodies than can either shrinkage or my method. On the other hand, when ground conditions permit, my method does not require that the broken ore be kept close up to the unbroken ore. An opening of a foot or two can be maintained, and "trails" or "benches" can be used, if so desired. I believe that the greatest advantages of my method over the sublevel method are its safety feature and also the fact that pillar recovery can immediately follow stope extraction. Some dilution in the pillar recovery would be expected, but this would be much less than if pillar recovery is delayed as is the case with sublevel stoping.

I believe the inherent difficulty in the method seen by Mr. Eaton is more imaginary than real; and, as far as costs are concerned, I have high hopes that I will soon be able to install the method and that we will have actual costs on which to base conclusions. As to its success if applied under the proper conditions I have not the slightest doubt, simply because each feature of the method has been tried and tested by years of use.

Tucson, Ariz. MORRIS J. ELSING.

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Ore-Reduction Expense

To the Editor:

Your editorial, "Comparing Per-Ton Grinding Costs," interests me. Recalling a recent conversation, I identify myself as the "veteran metallurgist."

Naturally, your emphasis is upon publication, which does not precisely express my thought, which was rather that there should be a full realization that grinding costs, as usually stated, are not to be accepted without analysis.

The value of comparisons of costs in different districts is doubtful. Screens have been standardized, but I am not aware of a successful method for calibrating a scale of hardness or toughness, whereby different ores may be referred confidently to a common standard. Rittinger's formula will throw light on the work actually done, even though it fails to discriminate between necessary work and the overgrinding, that, although unnecessary, is inevitable to every grinding operation. Power input and unit consumption of grinding media are definite items. But their cost is not uniform; and, more than this, accounting systems vary. All in all, the interpretation of such a group of figures must be a matter for individual judgment.

Grinding analyses of mill products are the best guide to plant control. Study of them usually discloses an additional recovery to be made by further reduction of particle size. Here the economic factor enters and the question of grinding cost arises. The question, however, is no longer general; it is specific; it is concerned with the cost of reducing the ore particles to pass some critical mesh.

What is this cost? Is it generally realized that grinding from plus-100 mesh to minus-100 mesh (to select this size as an example) ranges from at least 25c. to more more than 40c. a ton?

Costs are usually stated in terms of mill tonnage, and are allocated to the several machines without regard to the tonnage ground in the individual machine and without consideration of the size of feed and discharge. So stated, the range is from, say, 7c. to 15c. per ton.

In the series of Information Circulars issued by the U. S. Bureau of Mines, one may find the data needed for closer examination of the figures. As an example, a secondary grinding operation in a Southwestern mill is costing 7.8c. a ton. But this machine received but 55 per cent of the mill tonnage for further grinding, and this feed carried only 57 per cent of plus-100 mesh material. The discharge product still carried 14 per cent.

In this instance, then, the cost of reducing one ton of plus-100 mesh material to pass 100 mesh was:

$$7.8 \times \frac{100}{55} \times \frac{100}{57-14} = 32.9.$$

This is a typical and normal result.

Lead, S. D. ALLEN J. CLARKE.

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B. W. Lennon has joined the metallurgical staff at Mount Isa, Queensland.

E. G. D. Wright is now on the engineering staff of the Sao Paulo Railroad, Brazil.

W. A. Gosman has resigned as chief metallurgist of the Mount Lyell Company, Tasmania, after 32 years of service.

E. J. Dunn, formerly Government Geologist of Victoria, Australia, is consulting geologist to Clunes Goldfield.

Arthur Notman has been elected to the presidency of the Mining and Metallurgical Society of America.

Sydney H. Ball addressed the Royal Canadian Institute, at Toronto, on Jan. 23, on the subject of "The Diamond and the Diamond Industry."

Walter H. Aldridge, Henry Krumb, and **John V. W. Reynders** have been elected directors of the United Verde Copper Company.

Jack White supplied the photograph of the Beatty shaft at Roan Antelope that appeared on the front cover of the January issue. In response to inquiries: Exposure was for 1¾ hours, in the light of a near-full moon, with an aperture of F 4.5. Mr. White used a panchromatic plate.

J. P. B. Webster, director of Mining Trust, is on a visit to Australia, to inspect the company's properties at Mount Isa and in New Guinea.

C. F. Heathcote, managing director of Champion Reef Gold, in the Mysore district, India, is in Australia, on furlough.

T. A. Rickard is the author of "Man and Metals," a treatise in two volumes, to be published by the Whittlesey House Division of the McGraw-Hill Book Company in March.

E. Clarence Peterson, flotation metallurgist, has been engaged by Minerec Corporation and is now at Santa Barbara, Parral, Mexico.

L. W. Grothaus was recently appointed to succeed **C. F. Searle** (resigned) as general representative of the Allis-Chalmers Manufacturing Company.

Walter L. DuMoulin, connected with the New Cornelia mine of Phelps Dodge at Ajo., Ariz., since 1918, has resigned as general superintendent and is now at Phoenix, Ariz.

C. A. Banks, managing director of Bulolo Gold Dredging, Ltd., left San Francisco for Sydney and New Guinea on Feb. 2.

Walter Francoeur is metallurgist, and **E. G. Jones,** plant superintendent of Sorel Steel Foundries, Ltd., recently established in Montreal under the general managership of **P. H. Desrosiers.**

H. H. Herbert, formerly with Chile Exploration and Rhodesia Broken Hill companies, is now on the staff of the Indian Copper Corporation, operating at Ghatsila, Chota Nagpur, India.

Frank T. Leahy, formerly general manager of New Guinea Goldfields, has joined the board of directors of the Kaindi Gold Company, owner of leases in New Guinea.

Jules Labarthe recently returned to San Francisco from Northern Rhodesia. Professional work has also taken Mr. Labarthe in recent years to Russia and Canada.

Albert E. Keller, formerly chief mine accountant, U. S. Bureau of Mines, announces his return to private practice as a certified public accountant and office management engineer, with headquarters at 1372 Estes Ave., Chicago, Ill.

R. J. Goodwin, superintendent of the Ohio Copper property at Bingham Canyon, Utah, until suspension of operations in November, 1931, is now with the Death Valley Gold Mining Company, near Yucca Grove, Calif.

Austin F. Rogers, of the geological department of Stanford University, has identified a new barium silicate mineral, which he has named sanbornite, after Frank Sanborn, of the California Bureau of Mines.

J. D. Harlan, manager of Hammon Consolidated Goldfields at Nome, Alaska, who was in California recently, makes his headquarters at Fairbanks and commutes to Nome by airplane. He is also exploration engineer in the Alaska Yukon area for United States Mining and Fairbanks Exploration.

Ernest H. Davison (London University), who discusses the geology and metallurgy of Cornish tin ores in this issue, is head of the department of geology and mining at the Camborne School of Mines. Prospecting and examination work has taken him at various times to Africa, British Columbia, and Nova Scotia, between educational appointments and duties.

Sydney W. Smith, incoming president of the Institution of Mining and Metallurgy, is an associate of the Royal School of Mines and a doctor of science of London University. After acting as assistant to Sir William Roberts-Austin, he was appointed, in 1900, to a position on the technical staff of the Royal Mint, in London, where he is now chief assayer. Doctor Smith, who has made notable contributions to contemporary technical literature, has played an important part in conserving and consolidating the prestige and the high educational and professional status of the Institution.

C. Le Maistre, director of British Standards Association, is in Australia to confer with Australian Standards Association, of which **W. E. Wainwright,** general manager of Broken Hill South, is chairman.

A. E. Wheeler, consulting metallurgical engineer, of New York City, left for Moscow on Feb. 4. Mr. Wheeler expects to spend two or three months in Russia in connection with his work as technical adviser to the Soviet Government on non-ferrous metallurgy.

Bela Low calls attention to a draftsman's error in his article entitled "Determining Results Graphically in One-Product Concentration," published in the issue of Dec. 28, 1931. In the scale at the top of the chart on page 525, the figures 3.4, 3.5, 3.6, 3.7, and 3.8 should have been designated "Tailing Assays," thus distinguishing them from the scale 0.20-0.07 designated "Assay of Concentrate." A reprint of this article will be furnished to any subscriber desiring it. Address requests to Editorial Department, **Engineering and Mining Journal.**

J. H. Van Ketwich, managing director of the Dutch East Indies Government (Banka) tin sales offices, recently arrived in New York. Mr. Van Ketwich, whose headquarters are in Batavia, served last year on the Intergovernmental Tin Committee, as a member of the Dutch delegation. He will remain in the United States for a month or so, during which time he will make his headquarters at 40 Wall St., New York City, at the offices of Tuthill & Company, Inc.

Dorsey A. Lyon, director of the Utah engineering experiment station at the University of Utah, was elected president for 1932 of the Engineering Council of Utah at a recent meeting held in Salt Lake City. Doctor Lyon is also president of the Utah Society of Engineers. He succeeds **H. C. Goodrich** as president of the Council, and will serve during the year 1932. Other officers are **C. T. Van Winkle,** vice-president, and **George M. Bacon,** secretary-treasurer.

Benjamin L. Miller (Kansas and Johns Hopkins), who contributes the article in this issue on "Geology in the Non-Metallic Mining Industries," has been professor of geology at Lehigh University since 1907. Doctor Miller is a scientist, author, and consultant of high professional rank; and, by reason of intimate and successful work in the non-metallic industries, is particularly well qualified to open the discussion of a subject that deserves the serious attention of operators of non-metallic properties.

John L. Middleton, who contributes the article on mining in French Equatorial Africa in this issue, is a graduate of the University of Minnesota. Subsequent to geological and engineering experience in the Ray and Miami regions of Arizona, Mr. Middleton became Chief of Mission for the Forminière company in the Bas Uele and Haut Uele regions of the Belgian Congo. For the past three years he has been in charge of prospecting for Cie. Equatoriale de Mines, on the staff of which company he is chief geologist.

Obituary

C. W. MacDougall (Columbia, 1903), a member of the staff of the Quincy Mining Company, Hancock, Mich., until 1914, and assistant professor of mining at Lafayette College since that date, died recently.

James J. Sullivan, foreman of the Original mine at Butte, died of a heart attack on Jan. 9. Mr. Sullivan was born in Virginia City 42 years ago, and for the past twenty years had been engaged in mining at Butte.

John Bird Swift, former president of Eagle-Picher Lead Company, died at Cincinnati on Jan. 13. Mr. Swift was born in Cincinnati and had been engaged in business there since the age of seventeen. In 1916, when the Eagle-Picher Lead Company was formed, he became its head.

Alexander G. Whyte, vice-president of Walker & Whyte, Inc., assayers, of New York, died suddenly on Jan. 8, of cerebral hemorrhage. Mr. Whyte came from Canada 35 years ago, and had been associated with F. S. Hunt for the past 30 years.

John T. Norris, president of the Cherokee Ochre Company, Cartersville, Ga., died recently of heart failure. Mr. Norris was educated at Emory College and at the University of Georgia. He was active in civic affairs in Cartersville and was widely known and respected in mining circles.

John B. Annear died at Boulder, Colo., on Dec. 30, 1931, after a brief illness, aged 65. He was born in Troy, N. Y., was graduated, in geology, from the University of Colorado, and became actively engaged in mining in Boulder County, the San Juan basin, Arizona, California, and latterly was a member of the State Bureau of Mines at Denver.

Pierre Bouery, who died in San Francisco on Jan. 1 last, aged 73, was graduated from the Ecole Centrale de Arts et Manufactures, of Paris, then going to the Sudan, where he was engaged in engineering railroad development, later specializing in hydraulic and placer mining. He came to the United States in 1902, and for many years was manager of La Grange mine, in Trinity County, Calif. After a temporary retirement he returned to his mining practice, and he was active in consulting work up to the time of his death. His genial, happy personality won him many friends.

William D. Pomeroy, vice-president and general manager of Goulds Pumps, Inc., died on Jan. 6 after an illness of more than a year. A graduate in electrical engineering from Cornell University, Mr. Pomeroy joined the Bullock Electric Company, an Allis-Chalmers subsidiary, in 1895, as draftsman, eventually becoming works manager. He accepted the same position with the Goulds company in 1907, later being made director and vice-president. Mr. Pomeroy was a scholar and an engineer of high rank, whose passing is regretted by a large number of personal and professional friends and associates.

Concentration of Metallic Ores and Non-Metallic Minerals

A Review by B. H. Strom

FLOTATION. *By A. M. Gaudin. Pp. 552; illus. New York: McGraw-Hill Book Company; $6. London: McGraw-Hill Book Company, Ltd.*

Theodore J. Hoover, in his introductory remarks to this book, classes as one of its outstanding merits "that it much more fully than any previous attempt gives a practically complete exposition of the scientific principles underlying a process which is treating millions of tons every year." The reader is spared from wading through a long, drawn-out discourse on litigation and patent disputes—in many of the older works a hurdle to be cleared before the main topic could be approached. After a short chapter on essential historical data, the author plunges into what he terms "a technological record of the art, built on a scientific foundation and framed by its economic background."

Chapters II to IV present fundamental chemistry, with discussion of the physical phenomena encountered in the process; chapters V to VII, XIV, XV, XVIII, and XIX deal with general technology and treat such subjects as reagents, froth production, crushing, grinding, and classification, flotation machines, mill design, and testing; chapters VIII to XIII discuss detailed technology and practice, describing specific installations and illustrating the various problems by well-chosen examples from the field. The economy of the art, discussion of cost, choice of method to use, effect of the process on mining and metallurgical operations comprise chapters XVI, XVII, and XX.

Almost apologetically, the author wisely refrains from a lengthy discussion of such subjects as crushing, grinding, classification, or a detailed description of machinery, so that more space may be devoted to a thorough treatment of the fundamental processes. Too much emphasis can hardly be placed on this side of the art. Flotation furnishes an excellent example of the value of a correct application of scientific principles; it also demonstrates, more clearly than most other processes, the intimate relation between the various branches of chemistry and physics. From the chaos that existed a few years ago, definite theories are evolving, mechanical problems are being solved, the action of flotation reagents is gradually becoming understood; and, from the thousands of compounds available, the operator may, by scientific deduction, select those that best serve his specific need. In this work—closely connected as it is with and dependent upon the most advanced studies of the structure of matter and of intermolecular and interatomic forces—the author has been one of the pioneers. This probably explains why his presentation of this important but difficult phase of the art is so clear and so well executed that the subject becomes truly fascinating.

The technological development of the process is illustrated by flowsheets selected to present typical applications for numerous types of ores. Six plants treating copper sulphide ores are described, seven handling lead-zinc sulphides. Flotation of oxidized ores, and of rare minerals, including silver and gold ores, is also treated in detail. An interesting chapter is devoted to the flotation of non-metallic minerals; although development is still in the early stages, and a correct perspective is difficult to obtain, the results achieved in this field give promise of changes in practice that may become almost as far-reaching as those that have taken place in metallurgy. With a better understanding of the functions of reagents, separation of almost any combination of minerals comes within the realm of the possible. Although the problems here encountered may appear to be of a more difficult nature than those that confronted the metallurgist in the early days of the flotation process, accumulated experience and better understanding of the underlying principles should greatly hasten progress in the non-metallic field.

In his illustrations the author has to a large extent confined himself to American practice, which is natural. American engineers have played a prominent rôle in the development of the art. A contributing circumstance is doubtless also the willingness to release information and to exchange experiences in the technical press, so common in the United States, evidenced, for instance, by the many excellent reports on the operation of flotation plants issued lately by the U. S. Bureau of Mines. From all of these the author has drawn freely, as may be seen from the extensive list of references at the conclusion of each chapter, a compilation that should be of great value for the reader who wishes to go into details. The entire book, however, has a background of personal experience, which leaves no doubt that Mr. Gaudin has acquainted himself thoroughly with every phase of his subject.

In conclusion the hope is expressed that repeated editions of this valuable book will be forthcoming, to keep pace with changes and additions in the technique and scope of the process in the non-metallic as well as the metallic industry.

■ ■ ■

ONWARD INDUSTRY. *By James D. Mooney and Alan C. Reiley. Pp. 564. New York: Harper & Bros.; $6. London: Harper & Bros.*

The substance of this book is summed up in its subtitle: "The Principles of Organization and Their Significance to Modern Industry." The authors determine these principles by a lengthy, detailed analysis, and show how they are manifested in ancient, medieval, and modern forms of government—ecclesiastical, military, and industrial. This task accomplished—and its performance is marked by erudite discussion and nimble skippings from century to century, from civilization to civilization—they turn attention to the modern industrial organization, and sketch its development from the industrial revolution. In the end they consider the present status of industry, the conditions it has created, and the challenge these conditions offer to industrial leadership. That the problem of industrial humanics has not been solved, that on its solution depends the ultimate welfare of industry, is shown by the Russian undertaking, the authors say. Industry must be integrated for the common good; that is, with the justifying objective of universal human service, but not in the Communist way. Communism assumes the existence of an actual irradicable opposition of interests under our present system, but, ask the authors, cannot all human interests be reduced to a common denominator? This integration of industry must be voluntarily achieved by industry itself, all that is constructive in the spirit of competition being preserved. Such achievement will give industry a collective power it now lacks in human affairs, that will enable it to speak with far greater authority in the halls of legislation than could any dependent or restrictive interest.

Despite length and wordiness, the discussion is full of interest. One outstanding bit is the argument of the authors that development of machine production demands inexorably new forms of organization. The problems of production have yielded to those of distribution — in the United States. Abroad, the situation is different; but the notion that the present industrial ills of Britain and other Old World countries are the result of failure to emulate American mass-production methods is a false diagnosis, they say. The manufacturing countries of Europe understand mass production but lack opportunity to apply the principles involved, because of the relative absence

of mass markets, of a large coherent population having a common language and common needs, such as make mass production possible in America.

A. H. HUBBELL.

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POWER AND THE INTERNAL-COMBUSTION ENGINE. *By W. E. Dalby, F.R.S. Pp. 280; illus. New York: Longmans, Green & Company; $7. London: Edward Arnold & Company.*

Dr. Dalby's volume thoroughly describes the subject matter indicated in its title. The quantity of information presented, pertaining to the common principles and characteristics of structural design, and performance of the internal-combustion engine, the suction gas plant, and the petrol engine; and the clear discussion of the working agent, mixtures and fuels, and the heat flow and its effects on design, discussed in chapters 1, 2, and 7, make the book a valuable addition to the library of the student and practical power engineer. Included in the text are many helpful tables, charts, and illustrations, with specifications of the types of engines and auxiliaries. In general, the author has presented a wealth of good material in a clear, condensed, and interesting form.

■

AMERICAN MINING LAW. *By A. H. Ricketts; Bulletin 98, Division of Mines, State of California, San Francisco; $2, postpaid.*

This somewhat unusual publication for a state division of mines is justified by W. W. Bradley, state mineralogist, as an answer to many inquiries received. The subject is treated from an analytical and interpretative point of view, and supplements the treatise of Lindley. Mr. Ricketts published "Manual of American Mining Law" in 1911, and the present book is the result of mature experience in the practice of such law. Many citations and excerpts from decisions are given, and the bulletin should prove useful to the mining engineer as well as to the lawyer.

■

FUEL AND POWER IN LATIN AMERICA. *By J. R. Bradley, Washington, D. C.: U. S. Department of Commerce. Trade Promotion Series, No. 126; pp. 130; 25c.*

All important sources of energy in Latin America are shown in this monograph. Total consumption of coal, fuel oil, and water power in recent years is given. The study brings out the interdependence of nations in regard to power supply, the great reliance of Latin American industry on coal and petroleum, and the remarkable regional increase in the use of water power.

LAW OF PATENTS FOR CHEMISTS. *By Joseph Rossman. Washington, D. C.: Inventors' Publishing Company; pp. 304, with glossary; $3.50.*

Chemistry and metallurgy are so interrelated that the technician concerned with the treatment of ores, particularly their hydrometallurgical treatment, will find much of value in this treatise, which is written by the editor of the *Journal* of the Patent Office Society. As stated in the preface, the work aims to give a broad treatment, in language understandable to the layman, of the technical subject of patent law. The appendix contains an excellent glossary of terms, and a classification of the various branches of the art, according to Patent Office procedure.

■

SIMPLE DETERMINATIVE MINERALOGY. *By H. R. Beringer. Pp. 238. London: Mining Publications, Ltd.; 10/6.*

This text is a revised and enlarged edition of a book by the same author, entitled "Mineral Determination," published some years ago. It consists of a discussion of the use of specific gravity in determining minerals, a compilation of minerals grouped in order of their specific gravities, and a description of the physical characteristics of the minerals, arranged in the order of their specific gravities, which section makes up the major part of the book. The volume is comprehensive, the only minerals of Dana's numbered species omitted being the few of unknown specific gravity.

■

AUSGEWÄHLTE METHODEN FÜR SCHIEDSANALYSEN UND KONTRADIKTORISCHES ARBEITEN BEI DEN UNTERSUCHUNG VON ERZEN, METALLEN UND SONSTIGEN HÜTTENPRODUKTEN. *2 Auflage. Pp. 457. RM. 20. Probenahme von Erzen und anderen metallhaltigen Verhüttungsmaterialien sowie von Metallen und Legierungen. Pp. 108. RM. 4. Berlin: Selbstverlag der Gesellschaft Deutscher Metallhütten- und Bergleute e.V.*

Simplification and uniformity in treatment have been attained in the second edition of this book on analytical methods for ores, metals, and smelter products, issued by the German Institute of Mining and Metallurgical Engineers. With few exceptions the accuracy of all methods presented has been verified by exhaustive comparative tests. The fact that the methods have been accepted as standards by the committee on standards for non-ferrous metals proves the value of the book. Methods of sampling included in the first edition have been omitted and combined in a separate volume.

In consolidating the sampling methods for metals and residues, radical revisions and changes have been made. Suggestions from the metallurgical field have proved of much value in this work. The following subjects have been treated in an appendix, in conformity with the expressed wish of the field: Tolerable amounts of the common additions and impurities; splitting limits in analysis of smelter products and residues; German specifications and trade customs for scrap metals, clippings, and ingots; and American standard specifications for scrap metals.

■

THE ROEBLINGS. *By Hamilton Schuyler. Pp. 424; illus. Princeton: Princeton University Press; $5. London: Oxford University Press.*

This book, profusely illustrated with photographs of the Roebling family and its achievements, outlines the career of John A. Roebling, a pioneer in wire-rope manufacture and bridge construction, and describes the industry that his descendents have perpetuated.

■

HOUSE INSULATION, *Its Economies and Application. Department of Commerce. Washington, D. C.: Superintendent of Documents. Pp. 52; 10c.*

This is the report of one of the subcommittees of the National Committee on Wood Utilization, representing manufacturers, distributors, and consumers of forest products. Justification for mentioning it in these columns is twofold. First, insulation is a matter of importance to companies operating in very warm or very cold climates, who find it necessary to provide housing for employees. Indeed, in the temperate zones, also, it is worthy of consideration, a fact not yet sufficiently appreciated. Second, producers of certain non-metallic minerals, such as asbestos, diatomite, magnesite, and gypsum, find wood in direct competition with their respective products, so far as insulation is concerned, and therefore will be interested in the publicity thus obtained by their competitors.

The report states, further, that inasmuch as the National Committee deals primarily with forest products, materials other than wood are discussed only briefly. Mention of competitive materials is confined to saying, "Products manufactured from other raw materials may be equally effective and may give equally satisfactory service, and many of the statements made with reference to wood products apply as well to similar products made from other materials."

Economy and comfort are given as the outstanding reasons for insulating dwellings, it making possible lowered fuel costs and smaller heating plants. Where cooling is employed, moreover, air conditioning may be maintained

more economically in insulated buildings. Four types of insulation are considered: rigid, semi-rigid, flexible, and fill, these terms being descriptive of the materials themselves. Much of the pamphlet is devoted to discussing methods and cost of applying insulating materials in new construction, including insulating the house already built.

■

MICROSCOPIC DETERMINATION OF THE ORE MINERALS. *By M. N. Short. Geological Survey Bulletin 825. Sold by Superintendent of Documents, Washinton, D. C.; 60c.*

The author has been engaged for the last four years in developing improved methods for determining the ore minerals and collecting data pertaining to them. His book, wherein his experience is summarized, is divided into four parts, the first dealing with microscope technique, including mounting, polishing, and photographing specimens. Part 2 deals with physical properties, Part 3 with etch reactions, and Part 4 with microchemical methods. Part 3 is marked by the presentation of a 54-page detailed determinative table. Similar information marks Part 4.

■

SHALES AND BRICK CLAYS OF GEORGIA. *By Richard W. Smith. Bulletin No. 45, Geological Survey of Georgia. Pp. 348; illus. Georgia: Atlanta. Stein Printing Company; 25c.*

Detailed results of a recent survey of the clay and shale deposits of Georgia are presented in this volume—the third report on the subject that has been issued by the Geological Survey of Georgia. Since the last preceding report, which appeared in 1926, the clay-mining and clay-working industries of the State have expanded markedly. In this third report, Mr. Richard W. Smith, the author, who is Assistant State Geologist of Georgia, records the progress made in these industries, as well as pertinent geological data, results of laboratory tests, and descriptions of current processing practice. The book should be of value to those interested in the mineral resources of Georgia, and particularly to the ceramist or clay-product manufacturer who is considering the possibility of opening a clay-working plant in the state.

■

GEOLOGY OF PETROLEUM. *By W. H. Emmons. Second Edition. Pp. 736; illus. New York: McGraw-Hill Book Company; $6. London: McGraw-Hill Book Co., Ltd.*

This book, a comprehensive treatise of the geology of petroleum and natural gas, is equally well suited as a textbook or for reference purposes. Excellent illustrations add greatly to its value. A comprehensive bibliography is provided.

GEOLOGY AND INDUSTRY. *By Willard Rouse Jillson. Kentucky Geological Survey. Frankfort, Ky.*

In this small volume is presented the text of an address delivered by Dr. Jillson at Louisville last March and discussing the relationship between geological and industrial surveys. In it he argues that state geologists (of whom he is one), and the surveys with which they are connected, should not stop with the issuance of a geological or mineral-resource report or map, but should seek some agency or means for inducing the public to utilize these geological data. Such an agency nicely adjusted to the field of this special activity he sees in the modern Industrial Survey, be it maintained by business organizations, municipality, or state. A survey of this sort has been conducted in Kentucky, with a resultant quickening of the state's industrial pulse. An improvement has already resulted in a number of lines in spite of the prevailing depression.

■

Publications Received

MINING LAWS OF CANADA. *(Revised Edition.) Ottawa, Ontario: Department of Mines; 25c.*

GEOLOGY OF THE COUNTRY SURROUNDING NKANDHLA, NATAL. *By Dr. A. L. Du Toit. Pretoria, South Africa: Department of Mines and Industries; 5s.*

ALKALIEN UND ERDALKALIEN. *By Dr.-Ing. Bruno Waeser. Band XXVI, Technische Fortschrittsberichte. Dresden, Leipzig: Theodor Steinkopff; RM 13.50.*

MINING INDUSTRY OF IDAHO. *Thirty-second Annual Report for the year 1930. By Stewart Campbell, Inspector of Mines. Idaho: Boise.*

STATE GEOLOGICAL AND NATURAL HISTORY SURVEY. *State of Connecticut. Public Document No. 47. By W. E. Britton. Volume IX. Bulletins 43-48, 1928-1930. Hartford: State Geological and Natural History Survey.*

ANNALES DES MINES (BELGIUM). 1930. *Vol. XXXI. Brussels: Robert Louis, 37-39 rue Borrens.*

INVESTIGATIONS IN ORE DRESSING AND METALLURGY. *By officials of the Mines Branch, Department of Mines, Canada. Ottawa: Government Printer.*

BOLETIN DE MINAS Y PETROLEO. *January-March, 1931. Vol. IV, Nos. 25-27. Colombia: Ministerio de Industrias, Bogota.*

ANNUAL REPORT OF THE MINISTER OF MINES OF THE PROVINCE OF BRITISH COLUMBIA. *Year ended Dec. 31, 1930. Pp. 468; illus. Victoria, B. C.: Bureau of Mines.*

ESTADISTICA MINERA DE ESPAÑA. AÑO *1929. Pp. 699. Madrid: Sucesores de Rivadenevra (S.A.)*

STANDARDS OF THE HYDRAULIC SOCIETY. *Sixth Edition, comprising commercial and technical pump data, tables and charts. New York: The Hydraulic Society; $1.*

ANNUAL REPORT, ONTARIO DEPARTMENT OF MINES. *Illus., with Maps. Canada: Department of Mines, Toronto.*

OPTICAL INSTRUMENTS FOR EXAMINING AND ANALYZING METALS. *Illus. New York: Bausch & Lomb Optical Company, Rochester.*

ANNUAL REPORT FOR YEAR 1930. *By John T. Joyce. Pp. 64. Denver, Colo.; Bureau of Mines.*

GEOMAGNETIC SURVEY OF THE BAUXITE REGION IN CENTRAL ARKANSAS. *By Noel H. Stearn. Arkansas Geological Survey, Little Rock. Pp. 16, with several maps.*

POTASH BIBLIOGRAPHY IN 1929. (ANNOTATED). *By J. F. T. Berliner, Bureau of Mines, Washington, D. C. Pp. 578. For sale by the Superintendent of Documents, Washington; 90c.*

LABORATORY CONCENTRATION OF MISSOURI IRON ORES OF IRON MOUNTAIN AND PILOT KNOB. *By F. D. De Vaney and S. R. B. Cooke, Bureau of Mines and School of Mines, Rolla, Mo.*

ORIENTACIONES ECONÓMICAS. *Fernando Aguirre Errázuriz. Pp. 15. Estudio en los Anales del Instituto de Ingenieros en el número de Mayo de 1931. Chile: Imprenta Nascimento, Santiago.*

WORLD CRISES AND THE DEPRECIATION OF SILVER. *By C. P. Duarte. Pp. 27. Mexico: Treasury Department of Mexico, Mexico City.*

SILVER—SOME FUNDAMENTALS. *By H. M. Bratter. Journal of Political Economy, Vol. 39, No. 3, June, 1931.*

TRANSACTIONS OF CANADIAN INSTITUTE OF MINING AND METALLURGY AND OF MINING SOCIETY OF NOVA SCOTIA, 1930. *Vol. 33; pp. 614; illus. Montreal: 923 Drummond Building.*

ANNUAL REPORT COLORADO BUREAU OF MINES, 1930. *Denver: Bradford-Robinson Printing Company.*

SALT LAKES OF THE NORTHERN RIFT ZONE. *By D. Orr and D. R. Grantham. Dar Es Salaam, Tanganyika Territory: Government Printer; 4s.*

ANNUAL REPORT OF THE GEOLOGICAL SURVEY DEPARTMENT, UGANDA PROTECTORATE *—For Year Ended Dec. 31, 1930. Uganda: Government Printer; 3s.*

ANNUAL REPORT QUEBEC BUREAU OF MINES, 1930. *Part A—Mining Operations and Statistics. Quebec: Bureau of Mines.*

GEOLOGY OF THE EASTERN PART OF SANTA MONICA MOUNTAINS, LOS ANGELES COUNTY, CALIFORNIA. *By H. W. Hoots. Washington, D. C.: Government Printing Office; 75c.*

THIRTY-SIXTH ANNUAL REPORT OF THE MINERAL RESOURCES OF TENNESSEE. *Pp. 140; illus. Nashville, Tenn.: Department of Labor.*

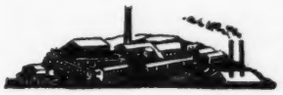
TENTH ANNUAL REPORT OF THE SECRETARY FOR MINES AND THE ANNUAL REPORT OF H. M. CHIEF INSPECTOR OF MINES FOR 1930. *Pp. 218. London; H. M. Stationery Office; 3s. 6d.*

ANNUAL REPORT OF MINES, 1930. *Part 2. Pp. 147; illus. Nova Scotia: Department of Public Works and Mines, Halifax.*

INVESTIGATION OF MINERAL RESOURCES AND MINING INDUSTRY, 1930. *No. 723. Illus. Canada: Department of Mines, Ottawa.*

HISTORICAL NOTES ON GEM MINING. *By Sydney H. Ball. Reprinted from "Economic Geology," Vol. XXVI, No. 7, Nov. 1930.*

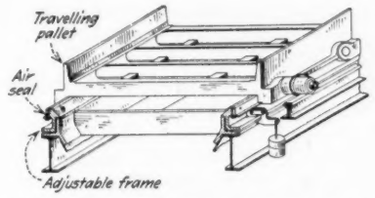
INDUSTRIAL PROGRESS



Improved Sintering Machine Air Seal at Mount Isa Plant

AN improvement in the Dwight-Lloyd sintering machine is the subject of an application for a United States patent by D. N. Morison, of Newcastle, N.S.W., Australia. This improvement was introduced in the first battery of sintering machines installed at the Mount Isa property, Queensland. The results are said to have proved satisfactory.

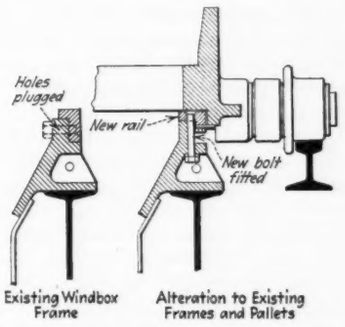
In the earlier type of machine the pallets were made sliding in contact with the top of the windbox. This produced wear and consequent renewals in vital parts. An improvement was introduced by supporting the weight of the loaded pallets on rollers attached to the pallet pins and taking the weight off the top of the windbox and transferring it to a parallel track. This reduced the power required to drive the machine and also the wear produced by the sliding contact between windbox and pallet.



An isometric projection of pallet and wind box in position, showing improved air seal

The lifting of the weight off the top of the windbox called for provision of means of making the windbox air-tight. Several devices were tried to make this air-seal effective. One involved the use of a renewable bar on the windbox and renewable strips on the bottom of the pallets where the latter and box were in air-tight contact on the side of the windbox top. These parts were subject to wear and could not be readily adjusted; consequently, the possible air leakage became worse and worse until the machine was stopped and the pallets were removed from the machine for repairs and the bar on the windbox was adjusted or renewed. Another device was the use of a spring strip which had a coefficient of expansion different from that of the pallets and boxes, but which buckled considerably, thus destroying its efficiency. Still another was the use of a loose fabric which was not proof against fraying and perishing and did not insure a true mechanical joint. All of these devices required the stopping or partial dismantling of the machine to make any alteration or adjustment.

The improvement made by Mr. Morison consists of (1) modification in the shape of the top of the windbox, making it possible for any adjustment desirable for clearance between the sides of the pallet and the windbox to be automatically or easily made while the pallets are in motion; (2) a modified shape of pallet providing for a continuous seal on the bottom of the traveling pallet; and (3) a continuous seal covering the narrow space between the new form of pallet and windbox. This seal does not cause any extra load on the driving motor of the sintering machine. It has the following characteristics also: It is made of materials of the same coefficient of expansion as the contact surfaces, consisting of a long thin steel or metal strip with or without a strip of asbestos compound similar to brake-lining material, the steel strip supporting the asbestos where necessary. It is almost out of sight, and free from liability of dust deposit, and is fastened to the adjustable part of the windbox. It can be easily adjusted, removed, or replaced while the machine is in motion. The advantage of this device can be calculated on the following basis:

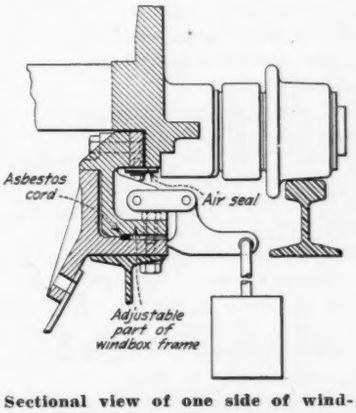


Sections indicating mode of applying wind-box seal to an existing machine

In the design of grates now commonly in use on a standard 42-in. machine, the area of the opening for the passage of gases into the windbox varies, according to local conditions and prejudices, from about 56 to 102 sq.in. when new, for each pallet of 24 in. in length. Through these openings pass gases, dust, and molten metal, and fine and coarse particles of sinter. Clinker, dust and metal adhere to the edges of the grate openings, materially reducing the effective area. An average area of the passage may be taken at 80 sq.in. Before the air reaches this opening, however, it has to pass through a more or less dense mass of materials to be sintered, about 5 in. or more in thickness. This obstruction reduces considerably the efficiency of the grate openings compared with a free and unobstructed passage from the atmosphere, as is frequently available between the bottom of the pallet and the top of the windbox.

The air, in passing through the ignited sinter, combines with these gases and is raised to temperatures from 400° to 1,000° C. according to local requirements or to the material treated before reaching the bottom of the pallet. Molten lead frequently passes through the grates, so that the temperature of the air and gases passing through the grate is in excess of the melting point of lead, —namely, 327° C. Let this temperature be taken as 339° C. or absolute T_o° of 612° C.

Any air that passes between the lower side of the pallet and the top of the windbox has a comparatively free passage over the machine faces.



Sectional view of one side of windbox frame and pallet with seal

Usually, the length of a pallet for the 42-in. machine is 24 in. The sectional area for this 24 in., with an opening of $\frac{1}{16}$ in. on each side, gives a total of 3 sq.in. The efficiency of this passage can be taken as unity. Air admitted here would have a temperature of the outside atmosphere, say 33° C. or an absolute T_o° of 306 deg. C.

Let the efficiency of the air passage through the sinter bed and grates be taken as 0.25. In cases of deep bed and slagged bars, even a coefficient of 0.25 may be too high.

The weight of air passing through each passage will be inversely as the absolute temperature.

The relative weight of air passing through each passage can be estimated from the following:

Let A = area of passage through grates — 80 sq.in.

B = area of passage under pallets— 3 sq.in.

a = efficiency of area A, say 0.25

b = efficiency of area B equal to 1

$T_a°$ = absolute $T_o°$ of gases passing through A = 612° C.

$T_b°$ = absolute $T_o°$ of gases passing through B = 306° C.

$\frac{1}{T_a°} : \frac{1}{T_b°}$ = relative weight of air at absolute temperatures.

The possible losses in efficiency of the draft through the sinter bed can be shown to be—

$$\frac{B \times b \times \frac{1}{T_b}}{\left(Bb\frac{1}{T_b}\right)+\left(Aa\frac{1}{T_a}\right)} \times 100 =$$

$$\frac{3 \times 1 \times \frac{1}{306}}{\left(3 \times 1 \times \frac{1}{306}\right)+\left(80 \times 0.25 \times \frac{1}{612}\right)} \times 100 = 23\%$$

This loss may be considerably more in the following cases: Where T° of hot gases from sinter bed is above 612° C., absolute; where the opening between the windbox and pallets is increased; where the passages through the grates become slagged and choked; and where a thick or dense sinter bed is carried and increases the friction to the necessary air supply.

The result is that in practice losses can easily be 50 per cent or over. This has been verified by actual experiment. The new device is said to prevent these losses effectively without any extra load on the driving gear of the machine.

A further advantage is obtained from an effective seal. Instances are on record of rapid corrosion of fan impellers, due, no doubt, to the action of elemental sulphurous or sulphuric acid fumes condensing on them.

An excess moisture in the sinter mixture will give off steam or aqueous vapor as the mixture comes in contact with the previously heated pallet returning for its new charge. As the loaded pallets pass into the ignition zone, more steam is generated and drawn into the windbox, there to meet with SO_2 from a later zone. The leakage of air under the pallet will provide further oxygen to complete formation of H_2SO_4 in the cooler zone of the suction fan. In certain climates this air may be moisture-laden and the results more serious. The new air seal is a distinct and effective block against this destructive air leakage into the windbox.

With the improvement described, Mr. Morison claimed that greater outputs can be obtained from existing plants; that deeper sinter beds are practicable; that considerable expense is saved by cutting out the usual stoppages for the purpose of adjusting the rails and removing and replacing of the pallets; that the wear and tear on the suction side of the pallets and top of the windbox is reduced, if not done away with; that the necessary power required on the fan motors can be reduced (horsepower for driving fans is about 1 hp. per square foot of sinter area), and as motors of 800 hp. are in use on the larger sizes of these machines, the saving in power consumption should be considerable through the elimination of the leakage of air under the pallets; that the constituents of the flue gases are under better control; and that the cost of the improvement is small relatively to the gains. The new device, he claims, can be applied to any existing plant at small expense.

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Continuous Vacuum Filtration Makes Advance in Processing Work

OF GREAT PROMISE to the non-metallic mining industry, and marking a departure from standard practice as to machinery used, is the dewatering of a non-metallic plastic material on a specially designed Oliver filter and the subsequent drying of the discharged filter cake in a specially constructed heat drying unit.

In the wet cement industry, disk filters of the American type have been working successfully for several years. Unusually good results have been obtained at a plant in Arkansas, where filter cake feed is being supplied to a 300-ft. gas-fired kiln, the longest yet adopted for this phase of cement manufacture. Some interesting applications are also being made of these filters by the Soviet Government in the Kola Peninsula, where a phosphate rock flotation concentrate is being dewatered.

The use of Oliver top-feed salt filters is said to afford an interesting application at one of the Texas Corporation's plants in Oklahoma, where salt brine produced by wells on the company's property is treated to remove magnesium salts and the final sodium chloride product is dewatered and dried on top-feed filters.

Recent developments in continuous vacuum filtration in the metallurgical field include the application in a zinc concentrator of top-feed Oliver filters equipped for heat drying, whereby the former plant, which included mechanical dewatering devices, a number of large bucket elevators and tower dryers, has been considerably simplified.

In cyanidation, significant work has been done in Ontario, where at Kirkland Lake and Timmins all plants have finally adopted double filtration as a standard step, and are using either Oliver or American filters for the purpose. Flotation as a means of recovering the bulk of the gold in the ore before beginning cyanidation is being seriously tried out in Ontario, though not yet adopted as standard practice. This is best seen at McIntyre-Porcupine's mill at Timmins, where double filtration of the cyanided flotation concentrate is being done. Likewise at Lake Shore will this scheme be tried, though not for recovering all the gold. Wright-Hargreaves is doing similar work. Also, in Western Australia, both the Wiluna and the Lake View & Star are using flotation and are cyaniding and double-filtering the concentrate.

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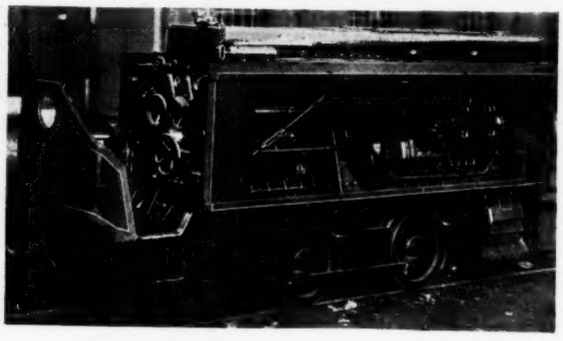
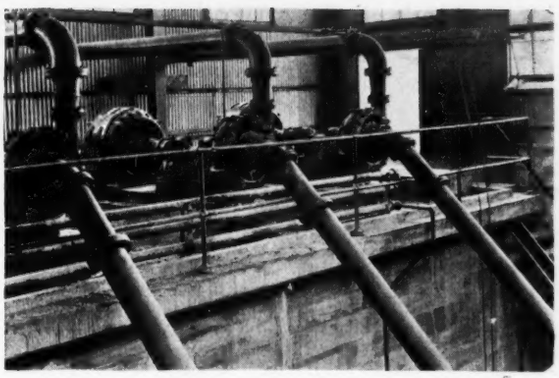
The Diesel Locomotive Underground

Mine locomotives powered with compressorless diesel engines are reported to have been used successfully underground in Germany. Their advantages are said to include absence of fire



Fire and gas hazard is said to have been obviated in the design of this diesel-driven mine locomotive



Abrasion-resisting rubber-lined pipe. Each pump handles 4,500 tons of chats daily

hazard and objectionable gases, cheapness of operation, insensitiveness to loads that are too high or too low, and unlimited radius of operation. An accompanying cut shows a locomotive of this type made by the Ruhrthaler Maschinenfabrik, at Mülheim-Ruhr. The fuel used is an inexpensive gas oil which can be ignited only when hot and finely divided. Backfiring is impossible with this type. Protection is supplied against sparks in the exhaust.

To remove further possibility of danger from the exhaust gases and to convert these gases into harmless steam, a spray of water under high pressure is introduced through a fine nozzle behind the exhaust valve. The water evaporates and makes all heavy residual matter in the exhaust drop out and collect on the walls of the exhaust pipe and in the muffler; this material eventually lodges in the water bath of the muffler and is removed at intervals. The water spray aids also in putting out the flames in the exhaust, thus adding to the safety in this respect. The exhaust gas as discharged thus contains steam with no harmful admixtures, so that the locomotive may be used in poorly ventilated drifts.

Compressed-air starting or electric starting may be used. With the former the motor itself produces the air, which is stored in a receptacle over the casing, whence it may be drawn as the driver wishes. If the pressure in the starting container is high enough, as indicated by a manometer at the driver's station, the feed valve is closed, and the engine is ready to start.

Suction Line Primer

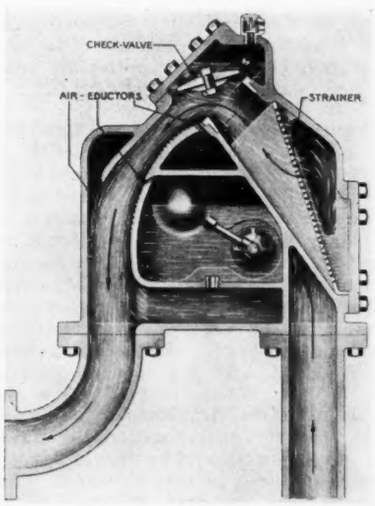
A new priming device for centrifugal pumps has been announced by Barrett, Haentjens & Company, Hazleton, Pa. It combines in one compact casting a check valve, strainer, and air-removing device. It is built in various sizes, for a maximum capacity of 1,500 g.p.m. and a maximum operating head of 200 ft. When furnished with a special control panel, it makes possible automatic operation of the pump with complete protection against loss of water, air leaks, break of the column line, and similar contingencies. The device is shown in an illustration.

Abrasion Resisted by Rubber Lining

Rubber-lined steel pipe handling chats 10 to 65 mesh in size is shown in an accompanying photographic reproduction. The chats are slime-free. Each pump with its section of pipe handles 4,500 to 4,700 tons daily, pumped at approximately 35 per cent solids. The pipe has been in service two years, without any part having to be replaced. The lining is ¼ in. thick, and of an abrasion-resisting rubber made by the B. F. Goodrich Rubber Company.

Safety Blocks for Mine Tracks

A mine-car safety block, consisting of three malleable iron castings, two of which, riveted together at the top, comprise a set of jaws which grip the ball of the mine rail, and the third of which acts as a clamp to lock the jaws to the rail in proper manner, has been introduced by the Mine Safety Appliances Company, Pittsburgh, Pa. The jaws slip over the rail easily and may be securely set in a few seconds, only one hand being required to do this. Their construction and design make them readily portable. By their use a workman on a track or in the face can prevent a car from running him down. This device is said to be so simple that workmen can readily be persuaded to use it.



An improved suction-line primer for automatically controlled centrifugal pumps

Two Magnetic Devices

An induction-type magnetic separator, having a wide range of application, has been developed by the Magnetic Manufacturing Company, Milwaukee, Wis. It is known as the Stearns Type K. In it one or more magnetic fields have been built into a single unit, making it able to handle not only materials ordinarily separated by high-powered separators but also those not heretofore considered amenable to magnetic separation. The unit combines its elements, it is said, so as to eliminate certain adverse conditions met in so-called high-intensity separators.

A new multiple-disk magnetic clutch has been brought out by the same company. It is made in torque ratings ranging from 3,700 (maximum) to 60,900 (maximum) lb.-ft.

Cement-making Machinery Improved

Two large Compeb mills were put into operation by Allis-Chalmers in 1931 for dry-grinding raw materials. Their capacity is said to have exceeded expectations. Both have three compartments, one 35 ft. long and the other 40 ft. over all. The mills are 9½ ft. in diameter in the preliminary compartment and 8 ft. in the finishing compartments. The air-separator circuit consists of classifying the material discharged from the first compartment with the production of finished material and a coarse reject which is sent to the second compartment. The second separator classifies the material discharging from the second compartment and produces finished material. Rejects are passed to the third compartment, which is operated in open circuit.

During the year the company made a number of improvements to its centrifugal vibrating screen and redesigned and improved its screw and log washers.

Improves Car Wheels

Increased hardness and resistance to abrasion and greater strength are claimed for molybdenum-chrome "semi-steel" car wheels which are now being offered by the Card Iron Works, Denver, Colo.

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INDUSTRIAL NOTES

Link-Belt Company, Chicago, has issued a data sheet (No. 4) presenting power formulas for chain conveyors and elevators.

Coppus Engineering Corporation, Worcester, Mass., has added the Annis air filter, a dry type, to its line. This filter is used on compressor and internal combustion engine intakes.

Interstate Equipment Corporation, 25 Church St., New York, will build a semi-automatic aërial tramway for San Antonio Gold Mines, Ltd., Winnipeg, Man.

NEWS OF THE INDUSTRY

UNITED STATES

Loring, Alaska, Jan. 12

Fairbanks Dredges Closed. The dredges of Fairbanks Exploration, largest producer of placer gold in Alaska, were all closed during December. The 1931 working season was comparatively longer than that of previous years during which this subsidiary of U. S. Smelting has been in operation. Work in the winter months is impossible because of the cold. Most of the company's dredges started in April. The first one to close was that on Lower Goldstream Creek. The two dredges on Wagner and McPike's Creek worked until the middle of December.

Chichagoff Mill Running. After being idle for several years, the Chichagoff mill on Chichagoff Island, in the Sitka district, was started operating in November and is now dropping ten stamps. At present the entire plant is being overhauled with a view to running at capacity of 150 tons of gold ore daily about March or April. New ore was opened in the Chichagoff workings in the middle of 1931. Originally opened on the 1,300 level, the company sunk on this ore an additional 113 ft. and is now drifting along the vein, which is 9 ft. wide.

San Francisco, Calif., Jan. 27

Alaska Juneau Development. Deep development in the North orebody on the Alaska Juneau property, Juneau, Alaska, continues to show excellent results, according to F. W. Bradley, president of the company. This work is being done through a three-compartment winze reaching to 600 ft. vertically below the Mill tunnel level. One cross-section, 512 ft. long, indicates an average profit of $1.50 per ton. Mining and milling costs for this deep ore are estimated at $1 a ton, so the grade is about $2.50.

Cut Mother Lode Wages. Wages on the Mother Lode, from which most of California's lode gold is produced, have been cut 10 per cent, effective Feb. 1. The gold-mine operators evidently feel that wage levels generally have been reduced and that by cutting their scales they will be able to handle lower-grade ore and thus increase production and employment. The new rate varies from $3.50 a day for surface labor, shovelers, and carmen, to $5.50 a day for surface hoist engineers.

Grass Valley Expansion. Production of gold from the Grass Valley district, which showed a healthy increase in 1931 over 1930, seems destined to climb further. The Murchie mine, recently acquired by Empire-Star Mines, Newmont's gold-mining subsidiary, has stopped milling operations. Empire-Star plans to sink the present shaft an additional 300 ft., increase underground development, and enlarge mill capacity. When production is resumed it will be on the basis of 500 tons of ore daily.

Idaho-Maryland, which has recently been handling about 175 tons daily at its two small mills, is planning to increase milling capacity to 400 tons daily. As the average yield is about $12.50 in gold per ton of ore, output may be as high as $150,000 monthly when the increase is completed. The company plans to unwater its Brunswick mine and undertake development of it.

At the Empress property, in the west part of the Grass Valley district, an important strike has been reported. The company has built a small mill and expects to begin production in February.

Balaklala Cons. Sold. Balaklala Consolidated Copper has transferred its copper properties, near Coram, Calif., to First National Copper, a Nevada concern. Balaklala has been closed since 1928, when it was operated under lease by Mason Valley Mines. The ore so far extracted averages about 2.5 per cent copper and can be recovered by open-cast methods.

Montezuma Builds Mill.—In the Nashville area north of Plymouth, Calif., the Montezuma property is erecting a ten-stamp mill. The mine workings have been unwatered to the 800 level and timbering has been repaired. New orebodies are said to have been exposed. Electric power lines were extended to the property.

New Idria Closed. The New Idria mine, largest individual producer of quicksilver in the United States, was closed down last month. The low price of quicksilver, which has dropped almost 50 per cent in the last year, is probably the cause. The property is southwest of Mendota, Calif., and has produced more than 350,000 flasks of quicksilver to date. Operations have been continuous since the new plant started work in 1923.

Trinity River Dredging. Lewiston Dredging has closed down its dredge in the Trinity River above Lewiston, Calif. The only dredger now at work in the Trinity River is the Smith dredge, as the Madrone dredge was shut down recently. A new dredge is under construction near the Paulson ranch. Mathews, Reynolds and Kinsman have leased the workings of the North Fork Placer Company's ground near Helena and have started work, with five men employed.

Virginia Mine May Reopen. The Virginia property near Coulterville, Calif., has been purchased by Fred Morris, mining engineer, of San Francisco. The Virginia was operated successively by White Gulch Mining, Virginia-Belmont Mining, and Nevada Hills Mining. It has a 1,000-ft. shaft, mining plant and ten-stamp mill. The mine will probably be reopened.

Gold From the Unemployed. Walter W. Bradley, State Mineralogist, has estimated that 10,000 or more itinerant men and women prospected in the gold region of northern California during 1931 and took out about $1,000,000 in gold. He estimated that they worked on an average of 90 days during the year and averaged a little more than $1 per day.

Yellow Pine Water Limited. The Yellow Pine gold-antimony property, in Valley County, Idaho, was to have started milling operations on Jan. 8, according to F. W. Bradley, owner of the property. Because of a shortage of power resulting from limited water supply, the full milling capacity of 250 tons daily cannot be utilized and only about 50 tons of ore will be milled until the present 100 hp. available can be increased. Grade is about $8 a ton in gold and 1 to 2 per cent antimony.

Wallace, Idaho, Jan. 28

Sunshine Reserves Down. Ore reserves of Sunshine Mining, operating Idaho's largest silver producer, in the Coeur d'Alene district, were 729,000 tons at the end of 1931. Of this, 279,000 tons, averaging 16 oz. of silver per ton, was blocked out, and the remainder, largely lower-grade material, was classed as probable. At the end of 1930, reserves were 787,000 tons. The company milled 173,168 tons last year. Production has been curtailed since Jan. 1, 1932, however, and the company is now handling only about 200 tons of high-grade ore daily. Half the force of 250 men was retained. The most important development work now under way is on the 1,700 level, where 900 ft. of ore has already been opened. A raise is being put up from the 1,700 to the 1,300 level.

Jack Waite Development. Drifting on the 200 level of the Jack Waite property, in the Coeur d'Alene district, has opened 300 ft. of mill-grade ore. Two crosscuts show widths of about 28 to 30 ft. This is the first work undertaken below the main tunnel level and is encouraging, as the grade ranges from 5 to 14 per cent lead. About 2 ft. of high-grade has been opened on the north side of the oreshoot. Shipments of high-grade ore and concentrate in December were 24 carloads.

Little Pittsburg Payment Made. Purchase of the Little Pittsburg property, on Pine Creek, in the Coeur d'Alene district, was completed in the middle of January, when Pine Creek Lead-Zinc made final payment to the owners. The company built a 200-ton flotation mill in 1930, after developing the vein through two tunnels, but operation was not undertaken, because of low metal prices. Control is held by Seattle interests.

Spokane, Wash., Jan. 25

Grandview Decides on Sale. Directors of Grandview Mines, operating in the Metaline Falls area, Washington, have approved the sale of their company's concentrator to Pend Oreille Mines & Metals. Payment of $100,000 will be made on the basis of $1 for each ton of concentrate produced. A right-of-way from the Josephine tunnel to the mill has been cleared, and a cable tramway will be built as soon as weather permits. At its own Josephine mill, Pend Oreille is now handling 290 tons of ore daily. Grade is said to be about 10 per cent zinc and 2 to 5 per cent lead. When enlarging of the Grandview mill, now having a 250-tion capacity, is completed, the company hopes to handle as much as 750 tons daily.

Mackay Metals Sold. The Mackay Metals property, near Mackay, Idaho, has been sold to M. G. Thomley. This mine, the largest copper producer in Idaho in 1929 and 1930, was closed down in August, 1930, because of the low price of copper, and has been closed since. Because of failure on the part of the owners to pay taxes, it passed into the hands of Custer County. Mr. Thomley has agreed to pay $25,000 if development results favorably. A 250-ton concentrator and a 16,000-ft. tramway connecting it with the mine are presumably included in the deal.

Reno, Nev., Jan. 28

Snow Hampers Nevada Mines. Although the heavy snowfall, so far this winter, has assured an abundant water supply for another year, it has for the time being stopped mining activities to a considerable extent in many part of the State. Near Reno, Castle Peak Quicksilver closed down a month ago, as it was known that the snow would block the roads into the camp. At Six Mile Canyon, an ample supply of provisions prevented suffering at the Belmont Uncle Sam mine. At Scossa, a foot of snow prevents prospecting, though men underground in the Noble shaft, the Hedwell, the Scossa Gold Mines, the Andy Miline shaft and the Scossa High Center tunnel are all working.

At Gilbert, Esmeralda Gold has had a carload of shipping ore held up two weeks, the roads being blocked for trucks. The big Treadwell Yukon truck was stalled three days with a six-ton load of coal for the Tybo camp. At the end of fourteen days, during which no one was able to get in or out of Camp McCoy, 30 miles south of Battle Mountain, Governor Balzar ordered the highway department to break the road through. The camp was known to be on short rations. A similar condition prevailed at Camp Valmey, and again the Governor ordered the roads cleared at the request of Senator L. A. Fredman, of Lovelock, who has several men at work prospecting a mine in the district.

Some of the supplies for Lucky Tiger-Combination Gold, which recently took over the Buckskin National property, 64 miles north of Winnemucca, got through, but the remainder is still at Winnemucca. The camp has an abundant food supply, except in some lines that might be regarded as luxuries, but a shortage of mine supplies is anticipated. The most heroic effort to keep a mine working was the taking in of men, supplies and a diamond drill from Elko to the Dexter mine, at Tuscarora. An airplane was secured from Salt Lake City. Three trips were made and the men and freight all landed. An airplane equipped with skis was not available in Nevada; hence the call on Salt Lake City. The Dexter mine, the banner producer in the early days of Tuscarora, has been optioned by the Independence Gold Syndicate, of Toronto, Canada.

Bullfrog to Build 200-Ton Mill. Since Aug. 20, 1930, when John Burmeister took over the Original Bullfrog and the Bullfrog Extension, in the old camp of Bullfrog, he has retimbered the Bullfrog Ex. shaft to 220 ft. and driven 2,400 ft. of lateral work on the 100 and 220 levels. A 25-ton pilot mill was built at Beatty, in which 480 tons of gold ore from various faces was treated. Recovery averaged $15 a ton, with $6.90 showing in the tailings. The small mill was equipped for amalgamation, concentration, and cyanidation. The flotation process is believed to be best adapted to the Bullfrog ores.

Albert Silver, Nevada engineer and mill builder, has designed a new 200-ton plant, to be erected at the mine, in which flotation will be substituted for cyanidation. It is reported by engineers that in the Bullfrog Ex. shaft workings 40,000 tons of $25 ore has been blocked out and about 500,000 tons that will average $8.50 per ton.

Nevada Con. Restricting. At the properties of Nevada Consolidated, in the Ely district, the working days have been cut from twenty to fifteen a month so as to restrict output of copper to 25 per cent of capacity. The company is reducing employees' rents, lights, water, and other charges. In recent months, operations at the Ely properties have been at about 35 per cent of capacity.

Salt Lake City, Utah, Jan. 28

Bingham Metals Opens Fissure. Three carloads of ore have been recently shipped from the Bingham Metals property in Bingham, adjoining Utah Copper, and two more are on the road. The ore, a copper-gold product carrying from $30 to $32 a ton, has been opened up in a fissure in the porphyry and is 5 ft. wide. It has been exposed for 50 ft. along the strike and for a depth of 50 ft.

Eureka Standard Cuts Rich Ore. A rich streak of ore has been followed for some time in the Eureka Standard mine near Dividend, Utah, controlled by Tintic Standard. Although not an entirely new development, the ore enriches the shipments considerably. Four 140-ton lots shipped during December contained an average of 10 oz. of gold and 50 oz. of silver to the ton. The highest assayed 15 oz. gold and 75 oz. silver and the lowest 4 oz. gold. The ore, a telluride, is found near the center of the property between the 1,100 and 1,300 levels.

International Buys Addie. The Addie Mining property was purchased by International Smelting on Jan. 27. Acquisition of this group of five claims, or about 90 acres, consolidates International Smelting holdings in the East Tintic district, inasmuch as the newly purchased acreage lies between the Yankee, Big Hill, East Tintic Coalition, and claims recently purchased from Chief Consolidated Mining. Several years ago, International drove a drift into Addie ground from the 2,000 level of the Yankee shaft. At present, the smelting company is advancing a drift westward from the 1,080 level of the Big Hill shaft to explore International holdings to the west and to develop the fissure struck on the 2,000 level of the Addie at its intersection with the Ajax and Cole Canyon limestones in the upper levels of the mine.

North Lily Development. In its East Tintic properties, International Smelting is conducting extensive development work. A winze is being sunk on the 900 level of the North Lily to develop the Eureka Lilly fissure, and from the 700 level work is being done to explore the formation north of the big orebody. From the Big Hill shaft in North Lily-Knight ground, the company is advancing a drift on the 1,080 to the west to develop the new ground acquired from Chief Consolidated. On the 1,600 level, the company is drifting into Eureka Bullion territory, in which a strong showing has been opened up.

Metal Production of Western States in 1931

State	Gold, Ounces		Silver, Ounces		Copper, Tons		Lead, Tons		Zinc, Tons	
	1930	1931	1930	1931	1930	1931	1930	1931	1930	1931
Arizona	169,400	123,500	5,540,732	3,157,000	288,095	198,800	4,246	775	815	.....
California	457,200	518,000	1,622,803	836,000	13,193	6,625	1,775	1,875	.....	.....
Colorado	218,470	230,574	4,290,587	2,074,591	4,894	3,861	22,768	6,729	36,279	15,988
Idaho	21,400	18,000	9,420,639	7,325,000	1,556	660	134,008	100,440	37,649	20,500
Montana	43,500	42,300	7,052,889	3,920,000	98,094	92,291	10,653	4,084	26,421	5,800
Nevada	149,065	142,000	4,219,832	2,496,000	54,602	36,023	11,529	7,950	14,584	9,120
New Mexico	32,730	32,228	1,107,335	1,042,000	32,575	31,596	10,378	10,411	32,765	28,181
Oregon	14,400	15,000	9,000	7,500	83	10	5	2	.....	.....
South Dakota	406,297	428,000	105,236	109,000	.....	.....	.....	.....	.....	.....
Utah	208,000	184,000	13,129,421	7,894,483	90,263	75,658	115,495	73,291	44,495	31,984
Washington	4,245	2,950	32,816	23,670	603	41	571	1,411	352	5,225

All figures from U. S. Bureau of Mines. In some items these figures differ sharply from those of the Bureau of the Mint, because they both represent preliminary estimates.

Utah Copper Curtails. On Jan. 1, Utah Copper, largest producer of copper in Utah, cut its monthly rate of copper production to 3,000 tons monthly. This is part of the general curtailment of copper output to 26½ per cent of capacity. Operations have been adjusted by giving employees fifteen days' work a month instead of eighteen to twenty days as heretofore.

Walker Copper, in which International Smelting has a substantial interest, has cut output from its property in Plumas County, Calif., to 250 tons of copper monthly. Miners are working four days a week. Capacity is close to 1,000 tons monthly.

Yankee Mines Shipping. Shipments from the Yankee Mines property, in American Fork Canyon, Utah, to the A.S.&R. Garfield smelter have been resumed at the rate of 50 tons daily after repairs to the new tramway, which caused a suspension of production for a period. The ore, a copper-gold-silver, is shipped from the mine over the 4-mile tramway to Deer Valley, where it is loaded on auto trucks and hauled to Pleasant Grove.

Miami, Ariz., Jan. 26

Inspiration Curtailment. On Jan. 1, 1932, more than 200 men were laid off by Inspiration Consolidated Copper, operating in the Miami district, and production of metal was cut to less than 25 per cent of rated capacity. The company had been operating about 40 per cent of capacity during the last six months of 1931. Inspiration is obtaining its entire production from oxide ores treated in the leaching unit, the concentrator having been idle for more than a year.

Katherine Mine Sold. The Katherine gold mine, on the Colorado River, west of Kingman, has been purchased by a Canadian syndicate headed by Edward Thornton, of Los Angeles. This property has been closed since the middle of 1929, when the operating company, owned by Californians, went into receivers' hands. It is equipped with a 300-ton mill and is reported to have a considerable tonnage of mill-grade ore available.

Gold Properties Active. A group of Eastern men has obtained an option on the White Bar gold property, consisting of 100 claims, 1,800 acres in extent, near Ruby, Santa Cruz County. One part of the area runs along the Mexican boundary. H. M. Powles, of Phoenix, represents the optionees.

The Comstock-Dexter group of claims adjoining the Hillside mine, in the Eureka district of Yavapai County, has been acquired by T. F. M. Fitzgerald and associates. The Humphries Investment Company, of Denver, has taken an option on most of the placer ground on Big Bug Creek between Mayer and Poland Junction, and is doing extensive sampling.

Tom Reed, at Oatman, recently completed a winze from the 950 level to the 1,100 level in the United American section of the mine, in which high-grade ore was found. From the 1,200 level a new winze is now being sunk which will probably go to the 1,400 or 1,500 level. Mines Holding, now in control of the Jack Pot and Merrimac properties, at Chloride, is keeping the water out of both mines and expects to start development work soon.

Wenden Opens Gold Area. A contract has been let for sinking a main shaft 600 ft. deep at the Vulture West Extension property, near Wickenburg, Ariz. Stock control of the property is held by Wenden Copper. Some ore from a 3-ft. vein has been sent to the old Vulture mill. About 1,200 ft. of trenching and 500 ft. of underground work have already been done on the property. The Wenden mine, at Wenden, has been shut down indefinitely, pending improvement in the price of copper.

Colorado Springs, Colo., Jan. 20

Granite Cuts Ore at Depth. Granite Gold, which is once again one of the leading shippers in the Cripple Creek district, has cut ore in the New Market vein on the No. 16 level of its Dillon shaft workings. A crosscut to this oreshoot is now being driven on the No. 14 level from the Dillon shaft. Attempts to find the ore by crosscutting from the 700 level of the Gold Coin shaft, reopened in 1930, have been unsuccessful to date. Shipments of ore by the company to the Golden Cycle mill totaled 32 cars in December.

Cresson Development. During the fiscal year ended Aug. 31, Cresson Consolidated did 8,865 ft. of development work at its Cripple Creek properties. Of this about 2,000 ft. was on development account. Several small orebodies have been opened and stoped. During the year, about 80,500 tons of ore was shipped, company ore having a gross value of $8.70 in gold per ton and lessee ore averaging $13.89 per ton. The company had total cash and accounts receivable of $298,160 at the end of the fiscal year.

Butte, Mont., Jan. 29

Butte Copper Con. to Reopen. Butte Copper Consolidated plans to resume operations at its Joe Dandy mine, near Radersburg. In 1927-29 this property produced a considerable tonnage of high-grade lead-silver ore. The company plans to sink the main shaft from the 600 to the 1,000 level. At a special stockholders' meeting, the capitalization was changed from 2,000,000 $1 shares to 4,000,000 50c. shares.

Basin Montana Cuts New Ore. A new orebody has been opened by Basin Montana Tunnel on its Nemo property, near Basin, Mont. The ore had been proved for a length of 50 ft. at last report and carried gold, silver, and lead. In addition, it persists in a 45-ft. winze sunk near the face of the Nemo tunnel, which is about 900 ft. south of the Grey Eagle workings and is at the same elevation as the lower Grey Eagle levels.

Laredo, Tex., Jan. 22

Antimony Tariff Request. — Texas Mining & Smelting, of Laredo, Tex., has prepared another application for an increase in the duty on antimony and antimony oxide for submission to the U. S. Tariff Commission. The original application for a higher duty was dismissed by the Commission on Jan. 18. The Texas antimony producer, in the latest request for a higher duty, points out that the material is being shipped from China to this country at a much lower price than it costs to make the domestic product, owing to cheap labor. Suspension of operations at the Texas plant may become necessary if relief in the form of a higher duty is not given the industry. The smelter operates on ore shipped from Mexico.

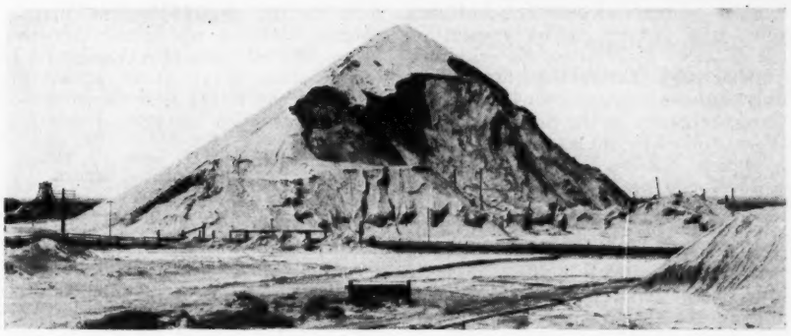
Uvalde Developing Kaolin. Uvalde Asphalt has taken over for development purposes the large deposit of kaolin situated 7 miles west of Leakey, Tex. It will make an initial shipment of two carloads of the clay to an Eastern pottery manufacturing plant as soon as it can be

Annual Reports of Mining Company Earnings

Company	Metals Produced	Location	Operating Profit	Net Profit	Net Profit Previous Year	Value Output	Dividends Paid
Ashanti Goldfields (*h*)	Gold	Gold Coast	£525,467	£422,509	£320,561	£750,579	£337,500
Associated Gold Mines (*a*)	Gold	Australia	(*b*)	£3,415	£4,659	£112,977	None
Cresson Consolidated (*c*)	Gold	Colorado	(*b*)	$101,967	$10,110	$793,419	$48,800
Huelva Copper (*d*)	Copper, pyrites	Spain	£12,301	£13,302	£40,381	£95,697	None
New Goldfields of Venezuela (*e*)	Gold	Venezuela	£6,061	£29,317	(*f*)	£105,829	None
Penawat (Malaya) Tin (*c*)	Tin	Malaya	(*b*)	£5,188	£16,239	£58,433	None
Sunshine Mining (*g*)	Silver, lead	Idaho	$62,005	$11,791	$77,965	$624,315	$29,776

In general, the figures for operating profit (or loss) represent the balance after deducting cash expenditures from the value of production. The figures for net profit (or loss) include the addition of sundry income, and the deduction of charges for depreciation, taxes, or other extraordinary expenditures. Because of the difference in accounting methods of different countries and different companies, the figures are not strictly comparable.

(*a*) Year ended March 31, 1931 (*b*) Not available. (*c*) Year ended Aug. 31, 1931. (*d*) Year ended June 30, 1931. (*e*) For period from Feb. 1, 1930, to June 30, 1931. (*f*) Not producing. (*g*) Year ended Dec. 31, 1931. (*h*) Year ended Sept. 30, 1931.



The tailing dump of Golden Horseshoe, at Kalgoorlie, Australia, showing the tonnage yet to be treated

mined and hauled to the shipping point at Leakey. This kaolin deposit has attracted the attention of manufacturers of fine pottery for many years, but on account of its inaccessibility to railroad transportation it has remained dormant.

Houghton, Mich., Feb. 2

C. & H. Operations. Ore mined by Calumet & Hecla Consolidated under its new curtailment policy is coming from the rich pillars above the No. 81 level in the conglomerate unit and from the three Ahmeek shafts on the Kearsarge amygdaloid. Grade of ore from the Ahmeek unit is not as high at depth as the ore mined formerly. Development work has been greatly curtailed. The program of exploration on the southern extension of the Kearsarge lode has been suspended, and only limited work is being done on the conglomerate below the No. 81 haulage level. Osceola shafts are completely shut down.

Hibbing, Minn., Jan. 26

Mesabi Range Safety Work. The best safety record since the establishment of the mine inspector's office in St. Louis County, Minn., was achieved by mining companies, according to Ed. Smith, county mine inspector. Four fatalities were recorded during 1931 operations, compared with nine for 1930. This was five fewer than the record safety year of 1928. Of 187 mines in the county, only 32 were in operation and 4,824 men were employed. A total of 22,000,000 tons of material was handled, iron-ore tonnage being 12,270,866. Of the ore tonnage 8,078,652 came from open pits and 4,192,214 from underground mines.

Credit for the improved record is given to carefully thought-out safety programs put into effect by all mining companies several years ago. During the year 4,258 men were trained in first aid and 68 in mine rescue work. This work was under the supervision of F. S. Crawford, district engineer, U. S. Bureau of Mines, Duluth.

New York, N. Y., Feb. 4

Homestake to Pay Bonus. Homestake Mining, largest gold producer in the United States, has declared an extra dividend of $1 a share, payable Feb. 25 to stockholders of record Feb. 20. This dividend is in addition to the regular monthly declaration of 65c. a share and indicates that 1932 disbursements will probably be at least $8.80 a share. The company has 251,160 shares outstanding. Production in 1930 was $8,426,195, and the 1931 estimate of South Dakota metal production indicates that in 1931 the company produced about $8,850,000. All save a few thousand of this is in gold. Ore mined from the property at Lead in the last two years has been of considerably higher grade than formerly and the margin of profit, per ton mined, has shown a corresponding increase. The company handles about 4,000 tons daily, grade now being about $7 a ton.

Ketwich Talks on Tin. J. H. Van Ketwich, managing director of the Banka Tin Sales Offices, Dutch East Indies Government, in an address before the American Tin Trade Association, Jan. 27, said that all governments in the tin quota plan have agreed to contribute a liberal sum for research. During the next five years, he pointed out, £28,000 is to be appropriated annually to expand present uses for tin, develop new uses, and preserve and strengthen existing markets where tin meets with competition. The work of the research council will include technical research, commercial publicity, and the compilation and publication of tin statistics. As the United States is the world's largest consumer of tin, a great deal of the research work will have to be done here.

Touching on the future of tin, Mr. Van Ketwich said that it is quite clear that only a general improvement in the world economic situation can bring about a material increase in tin consumption. If the world rate of business activity in 1932 is going to decrease further, and to the same extent as in 1931, a further cut in tin production to keep it in line with consumption may be necessary. The International Tin Restriction Committee will in such an event be prepared to make new curtailment recommendations to its member governments. Tin consumption figures for Europe during the past four months indicate some slight improvement, but consumption in the United States as yet shows no noticeable betterment.

Mr. Van Ketwich later announced that the member governments have appointed to the General Council of the Intergovernmental Tin Research Committee the following members: For Bolivia, Mr. Roberts; for Malaya, Mr. Cochrane, formerly First Secretary to the Federated Malay States, and C. V. Stephens, prominent in Malayan tin and rubber affairs; for the Dutch East Indies, J. van der Broek, one of the managing directors of the Billiton company; and for Nigeria, Sir Frank Baddeley, formerly First Secretary to Nigeria, and John H. C. E. Howeson, prominent in Nigerian and Malayan tin affairs.

Manville Reduces Wages. Johns-Manville Corporation, largest factor in the asbestos market, reduced wages 10 per cent on Jan. 1. Salaries were cut from 10 to 15 per cent. The company has asbestos-mining subsidiaries in Quebec and Arizona which were presumably affected by the wage cuts.

Bob Suit Legal. The Appellate Division of the Supreme Court of New York has reversed the decision of Justice Erwin Untermeyer with respect to the suit brought by C. V. Bob, mine promoter, against a group of financiers for damages amounting to $25,000,000. Justice Untermeyer had denied Bob the right to sue. Control of Golden Centre and other mining stocks promoted by Bob is involved.

Joplin, Mo., Jan. 30

Eagle-Picher's New Mill. Construction of the new 3,600-ton mill that Eagle-Picher Mining & Smelting is erecting to handle ore from its mines in the Tri-State district will be started as soon as work of laying railroad sidings has been completed. The work will be speeded to help relieve local unemployment. The concentrator will be similar to the Bird Dog plant of Commerce Mining & Royalty and will mark a further step in the evolution of central milling practice in the Tri-State district, as it will replace a large number of small plants now operated by the company. Eagle-Picher M.&S. is a subsidiary of Eagle-Picher Lead.

Tri-State Concentrate Stocks. Shipments of lead concentrate from the Joplin field were considerably higher in January than in any month in 1931, with the result that the stocks in bins were reduced by about 3,000 tons to less than 20,000 tons. Zinc concentrate has been moving slowly. With zinc at about 2.85c. a pound and concentrate at $17 a ton, further curtailment of production seems unavoidable. Zinc concentrate stocks are now not much under 90,000 tons.

World Zinc Production
A.B.M.S. figures, short tons

	Oct., 1931	Nov., 1931	Dec., 1931
United States	21,674	10,526	21,965
Mexico	2,809	2,972	3,105
Canada	8,399	7,835	7,262
Belgium (a)	12,410	12,190	11,883
France	5,136	4,967	4,650
Germany (a)	4,437	4,302	4,165
Italy	1,221	1,261	1,265
Netherlands	1,653	1,552	1,500
Poland (a)	10,859	10,236	9,305
Spain	914	841	868
Anglo-Australia	6,436	6,261	6,346
Rhodesia	.....	.....	.....
Elsewhere (b)	9,000	8,900	8,400
Totals	84,948	81,843	80,714

(a) Includes salable zinc dust. (b) Partly estimated; includes Norway, Yugoslavia, Czechoslovakia, Russia, Indo-China, and Japan.

World Lead Output
A.B.M.S. figures, short tons

	1930	1931
January	153,772	146,710
February	148,298	138,120
March	163,177	146,789
April	153,779	131,926
May	157,270	123,639
June	150,541	119,840
July	151,356	114,419
August	155,364	121,010
September	148,506	109,629
October	152,616	117,984
November	144,525	119,398
December	153,840	122,691
Totals	(a) 1,833,281	1,512,155

(a) Revised annual total.

Conway, Ark., Jan. 20

Pulaski Gets Lease. Pulaski Mining has been given a lease on 54 acres of state-owned land known as the Confederate Home property near Sweet Home, Ark. The lease calls for a minimum payment of $10,000 annually, plus a royalty per ton of ore produced. The royalty ranges from $1.05 to $1.80 per ton, depending on the grade. Production does not have to start until after 1933. Pulaski Mining is a subsidiary of Dixie Mining, now operating bauxite properties near Sweet Home. Estimates place the tonnage available on the Confederate Home ground at several hundred thousand tons.

Tampa, Fla., Jan. 11

Dunellon Spur Complete. A short railroad spur connecting the Dunellon Phosphate property with the Atlantic Coast Line, near Inverness, Fla., has been completed; likewise the four-log washing plant. Mining operations started about six months ago with the removal of the 40-ft. overburden. This work is being done with a hydraulic gun, and an average of 2,000 cu.yd. of sand is being removed daily. The steel hull of the Tampa dipper dredge has been completed, and installation of the power machinery and the boom has been in progress for some time. The dredge is equipped with a 1½-cu.yd. bucket. Two Link-Belt 1-cu.yd. capacity gas shovels will be used to remove and load the phosphate-bearing bed from the dry section of the pit. Buildings recently completed include the general office and repair shops. E. Ludwig is general superintendent. Operations, according to present expectations, will be started within 30 days.

Asheville, N. C., Jan. 25

Purchase Large Mineral Area. A syndicate headed by Howard D. Marmon, of the Marmon Motor Company, is reported to have purchased a 4,000-acre tract in Avery and Mitchell counties, N. C., for $100,000. The area carries feldspar, mica, and kaolin deposits, on which a crew of men have been doing development work for several months. No announcement has been made of plans for exploitation of the deposits. North Carolina is already an important factor in the production of all three non-metallics.

Washington, D. C., Jan. 29

Contending that investigation and research work should now be reduced to a minimum, the House Appropriations Committee has cut the appropriation for continuation of the mineral resources survey of Alaska by the U. S. Geological Survey during the next fiscal year. The Interior Department appropriation bill, recently sent to the floor of the House by the committee with reductions in practically every item, makes $67,500 available for the Alaska survey. Last year an appropriation of $84,500 was made for this survey. The committee rejected the recommendations of the Budget Bureau that last year's appropriation be equaled in the new bill.

Copper Tariff Resolution. On Jan. 27 Representative Douglas, sole Arizona member of the House, introduced a joint resolution asking for a tariff of 5c. a pound on copper, copper products, and the copper contents of ores, concentrates, regulus, and mattes. The resolution, which declares that Arizona's economic and social organization depends almost entirely on the copper industry, states that an emergency of the first magnitude has been caused by the astounding speed with which foreign copper producers have developed practically inexhaustible ore deposits. The resolution has been referred to the Ways and Means Committee. Several other bills asking for a copper tariff are already before Congress and the Senate has received a memorandum from the Tariff Commission comparing foreign and domestic costs of production.

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SOUTH AMERICA

La Paz, Bolivia, Jan. 4

Tin Mines Find Going Easier. The condition of the tin-mining industry has been slowly improving during the last few months. The improvement has been due to the rise in the tin price corresponding to the drop in the gold value of the pound sterling, and to the fact that the boliviano has been kept at a constant exchange with the pound sterling. This exchange has been in the neighborhood of 13 bolivianos per pound sterling. Miners in Bolivia are hoping that during January this exchange will be dropped to 15 bolivianos per pound sterling. This change has been promised, and would be a decided help to the miners in the matter of wages. Mining conditions continue to be so difficult generally that no tin mine is operating today at an actual profit. None of the mines that have been shut down have even considered starting up again.

Rainy Season Helps Placers. With the coming of the rainy season, gold placer prospecting will start. Those of the tin mines that are depending largely on tributors for production may be expected to do better for a few months. The Easley and Inslee scheelite mine, at Condeaqui, is now resuming production also.

London, England, Jan. 23

New Goldfields of Venezuela. Production is being increased at the property of New Goldfields of Venezuela, in the Bolivar district, Venezuela, and the tonnage milled is now about 250 daily. When a sufficient number of miners can be obtained the full mill capacity of 500 tons will be used, as underground development has been successful in increasing the ore reserves. On June 30, 1931, reserves were 535,388 tons averaging 9.9 dwt. in gold per ton. In one area, J. A. Agnew, chairman of the company states, 55 ft. of ore averaging 26 dwt. in gold over a width of 7 ft. has been developed. As yet, the projected tramway to connect the company's Bolivar unit with the mill has not been built, and the entire tonnage is coming from the Beru unit. Cost of a tramway is estimated at £12,000 to £15,000.

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MEXICO

Mexico City, Mexico, Jan. 30

Cusi-Mex. Closing Opposed. The Chihuahua state government has been petitioned by municipal officials of Cusihuiriachic to exert efforts to induce Cusi-Mexicana Mining not to suspend operations. Cusi-Mexicana, the only large operator in the district, has closed its properties and is now running only its pumps. The mill has been operating at about one-third of its capacity, although production in 1931 was more than 1,000,000 oz. of silver. Developments on the Santa Eduwiges and Hortensia veins have been favorable at depth. Municipal officials hope that the company can be persuaded to work on a three-day-week basis to keep the 500 employees at work.

Michoacan Gold Discoveries. Promising gold discoveries have been made in Michoacan, about 3 km. from Santa Ana Maya, according to official reports. The discoverer was Santiago Zamora, Mexican prospector. More than 200 applications for claims in the discovery zone have been received by the Department of Industry, Commerce and Labor.

Sonora Placer Enterprise. Exploitation of the Llanos de Oro and Cienega placer fields, in the Altar Valley, Sonora, Mexico, is being undertaken by Altar Placer, a company backed by California and Arizona capital. The properties are about 100 miles south of the international border. According to Ramon Elias, of Tucson, Ariz., a caterpillar steam shovel will be used for extracting the gravel.

Tambor Claims Reinstated. The Sinaloa state government has reinstated the rights of persons who can prove ownership of claims in the Tambor gold district, first discovered about a year ago in San Ignacia municipality. Because of the general confusion which prevailed over ownership rights in this new placer field, the state had given individual prospectors permits to work the placers. As a result, several hundred prospectors are being forced to leave the field. The state government feels, however, that by restoring ownership rights, large-scale exploitation of the deposits will be made possible.

Austin, Tex., Jan. 25

Urges New Zinc Smelter. Construction of a zinc plant to smelt ore and concentrate is recommended by F. E. Salas in a survey of the zinc industry of Mexico, made at the request of the Mexican government. Monterey or some other city close to the chief sources of supply is suggested as a suitable site. At present, Mexico has only one operating zinc smelter, that of American Smelting & Refining at Rosita, Coahuila, which has a capacity of about 50,000 tons of zinc annually. The rest of Mexico's output is exported for smelting in Europe. In 1928, output of high-grade zinc ore and concentrate was 342,012 tons, Mr. Salas points out. Lack of smelting facilities in Mexico has closed many mines, he declares.

AFRICA

London, England, Jan. 23

Transvaal Record Production. Output of the gold mines in the Transvaal in 1931 was 10,874,145 oz., the highest it has ever been. In 1930, which held the record previously, output was 10,719,760 oz. Of the 1931 output, 518,964 oz. was produced by mines outside of the Witwatersrand. Included in this category is production of Sub Nigel, which, in many ways, should be considered a Rand mine. However, even at 10,355,190 oz., the Witwatersrand output creates a remarkable record for a single district. Although no definite forecast can be made for 1932, the 1931 output will probably be equaled. The Meyer & Charlton mine, which has contributed about 40,000 oz. annually in recent years, will soon suspend production, and some of the East Rand mines, such as New Modder, will report a lessened output because of lower grade. On the other hand, East Geduld and Daggafontein, the two new East Rand producers, together should produce close to 400,000 oz. in 1932, compared with East Geduld's recovery of about 60,000 oz. in 1931.

Roan Antelope Financing. Roan Antelope, operating in Rhodesia, is issuing 750,000 additional shares at a price of 7s. 6d. The company obtains £262,500 net cash, as the issue has been underwritten for 6d. per share. The money is to be used for financing current output. Roan is selling a portion of its production without electrolytic refining. During December Roan Antelope shipped 295 short tons of 54.93 per cent copper concentrates and 4,164 tons of blister copper averaging 99.72 per cent. As 159,900 tons of ore averaging 3.78 per cent was milled, shipments apparently did not cover the full production. Less ore than the capacity of the plant was treated, also, this probably reflecting the retrenchment which was under way in preparation for curtailment to the company's quota, which began when the month ended. Copper content in the blister and concentrates shipped was about 4,333 tons.

N'Kana Production. The N'Kana mill of Rhokana Corporation started on Dec. 11, and has run continuously since. Production figures will not be published at present. Officials express themselves well satisfied with the results of the initial operations of the plant. The output capacity of the present plant has been rated at 150,000 short tons of copper annually. By handling high-grade ores this production is possible from the treatment of between 7,000 and 8,000 tons daily. When the demand for copper expands sufficiently to warrant it, Rhokana's properties can readily be developed and equipped to supply and treat 15,000 tons of ore daily, and eventually as much as 30,000 tons a day. Ore reserves can supply 30,000 tons daily for 25 years, and there are no physical obstacles to the operation of the properties on such a scale.

To assure the economic treatment of the rich mixed oxide-sulphide ore in the N'Changa-West area, a pyrite mine has been acquired to supply such sulphur and iron as may be needed for fluxing, and the smelter is designed to carry out the process of reduction this suggests. The development of a method of treating the lower-grade oxide ores will thus evolve naturally from practical operating experience.

E.&M.J. Weighted Index of Non-Ferrous Metal Prices

100 Is Composite for 1922-3-4

1920	130.92
1921	80.80
1922	93.94
1923	103.43
1924	102.63
1925	111.74
1926	107.74
1927	97.54
1928	99.78
1929	110.33
1930	82.87
1931	60.20

	1930	1931	1932
January	102.94	67.62	54.87
February	102.28	65.90	....
March	99.93	68.03	....
April	93.24	64.45	....
May	83.41	59.81	....
June	78.57	58.23	....
July	74.58	59.54	....
August	74.41	58.05	....
September	73.42	57.09	....
October	69.63	55.08	....
November	71.39	54.91	....
December	70.65	53.77	....

Ariston Expects Lower Costs. Ariston Gold Mines, operating the Prestea property, Gold Coast, expects to cut its mining and milling costs from the average of 38s. 10d. to about 30s. per ton, according to a statement at the meeting on Dec. 31. Operations are being increased to a capacity of 6,000 tons monthly. During the year ended Sept. 30, 1931, the mill crushed 51,626 tons of ore, recovering 8.7 dwt. in gold per ton. Ore reserves at the end of the year were 161,074 tons averaging 11.7 dwt. per ton. The two shafts are now down to about 2,300 ft., preparatory to development of the No. 17 level. Succeeding levels will be developed through a new internal shaft.

Ashanti Reserves Higher. On Sept. 30, 1931, ore reserves at Ashanti Goldfields, leading gold producer on the Gold Coast, were 667,400 tons of ore averaging 23.1 dwt. in gold per ton. This compares with 607,600 tons averaging 24.7 dwt. at the end of the previous fiscal year. Developments on the three bottom levels of the mine have added a considerable tonnage to the reserves, but the grade is below average. Since the end of the fiscal year, two crosscuts on the No. 26 level, deepest in the mine, have shown widths of 90 and 32 ft. of ore averaging 11.5 dwt. Development of the Cote d'Or reef may have to be undertaken through a new shaft, as work on this reef on the Nos. 19 and 18 levels is at a considerable distance from the present shafts. A crosscut to the location of the new shaft on the 1,000 level is being driven from the Obussi workings.

Dividend declarations by the company for the fiscal year total 90 per cent of the capitalization of £375,000, and, in addition, one new share is being given to stockholders for each three held, thus increasing outstanding capital to £500,000.

Mamre Handicapped by Water. Water shortage has handicapped operation of the new gold mill at the Mamre Gold property, in eastern Transvaal. At June 30, 1931, ore reserves were 59,315 tons averaging 6.85 dwt. in gold per ton over a width of 53.6 in. The mill has a capacity of 100 tons daily.

Messina Opens New Ore. Development in the Grenfell orebody, at the east end of "K" lode of the Messina (Transvaal) Development property, at Messina, Transvaal, has shown 40 ft. of ore averaging 5.5 per cent copper, according to Lieut.-Col. J. P. Grenfell, chairman of the company. This ore is on the No. 11 level and indicates a new high-grade orebody. The "K" lode has already about half of the total ore reserves of 1,240,000 tons averaging 2.75 per cent copper.

Brussels, Belgium, Jan. 18

Congo Gold Output. Reports of output in 1931 by the two leading producers of gold in the Belgian Congo indicate that the colony greatly increased its gold yield. In 1930, the total output was 194,154 oz., of which 147,799 oz. was produced by Kilo-Moto Gold and 31,282 oz. was produced by Grands Lacs Africains. For 1931, Kile-Moto reports output of 170,003 oz. and Grand Lacs an output of 36,940 oz., or a total of 206,943 oz. Contributions of small mines should bring the Congo output up to at least 225,000 oz.

In 1932, Kilo-Moto expects to produce about 180,000 oz. A light railroad is being built to the mines from a navigable tributary of the Upper Congo River. Systematic development of the alluvial deposits held by Grand Lacs has increased the total gold in reserves, according to officials of the company. At the end of 1930, reserves contained about 240,000 oz. in gold.

Minière du Kivu Formed. The Comité National du Kivu has formed a subsidiary, Société Minière du Kivu, to continue prospecting and development in the eastern Congo. The capital of the mining company will be 25,000,000 fr. Alluvial gold and tin, lode tin, coal, and oil have been discovered in the area, according to M. Rutten, chairman. Another company, Compagnie du Kivu, is forming a subsidiary, Société Minière du Mukinga et de Kigali, to work tin and gold discoveries in Ruanda. Tin reserves are stated to be 100,000 tons of cassiterite yielding 75 per cent tin.

Union Minière Curtailment. Curtailment of operations by Union Minière, leading Belgian Congo copper producer, has resulted in cutting the number of the company's white employees in the Congo from 2,500 on Jan. 1, 1930, to about 800 early in December. Improvements in Union Minière's plant have accounted for part of this reduction, but curtailment is responsible for the larger part of it. Reports have been published that the high-grade sulphide orebody discovered by the company on the Katanga railroad, between Mokambo and Tshinsenda, contains as much as 115,000,000 metric tons of ore.

EUROPE

Stockholm, Sweden, Jan. 10

Boliden Completing Plant. By June, operations of Boliden Mining, in northern Sweden, are expected to reach capacity of 50,000 tons of ore monthly. Development work in the mine and construction at the Rönnskär smelter have been virtually completed. Production will be about 750 tons of blister copper monthly, the blister containing 1,350 grams of gold per ton. This is the equivalent of about 10,000 kg. annually, or about 320,000 oz. of gold, which will make Sweden the largest gold producer in Europe. To date about $8,000,000 has been spent in construction.

Average grade of ore at Boliden is 2.5 per cent copper, 30 per cent sulphur, 10 per cent arsenic, 70 grams of silver, and 20 grams of gold per ton. Development has proceeded on four levels, at 165, 295, 430 and 560 ft., and a fifth level, at 690 ft., will soon be opened. The deepest shaft is now at 900 ft. The 430 level is the deepest that has been completely developed to date and shows a total vein area of 124,000 sq.ft. At its widest point, the vein is about 140 ft. wide. To date, about 285,000 tons of ore has been mined from this deposit, discovered in 1925. Of this, 70,000 tons of high-grade was shipped to German and American smelters.

Annual capacity of the smelter, which has been in operation since the middle of 1930, will be about 450,000 tons of ore when expansion is completed. The plant is at Rönnskär, near Skelleftea, on the Baltic Sea, about 40 miles from the mine. After crushing and hand sorting at the mine, the ore is roasted in mechanical furnaces, each with a daily capacity of 115 tons, at the smelter, and then reduced in a reverberatory furnace. Blister copper will be cast into anodes and refined electrolytically. Cottrell treaters will recover the dust, which is expected to carry comparatively high arsenic and precious-metal contents. As production of arsenic is 55,000 tons annually, and a market exists for only about 10,000 tons, a large storage bin has been built to which the arsenic is conveyed mechanically.

About 550 men will be employed at the mine and about 500 at the smelter. The company has built carefully planned towns at both sites, capable of providing about 4,000 inhabitants with running water, gas, electric light, and modern sanitary conveniences.

Berlin, Germany, Jan. 21

Quicksilver Cartel. Mercurio Europeo, the Spanish-Italian quicksilver cartel, has transferred some of its sales activities to the London firm of Roura Forgas. In the sales agreement the latter is to take 30,000 flasks yearly for the next three years. Italy is to participate with 12,000 flasks. Monte Amiata is credited with holding about 50,000 flasks of quicksilver, whereas its annual quota in the cartel is only 6,000 flasks. The other Italian producers, according to reports, also hold large stocks. Monte Amiata, which is controlled by the government, is operating three days a week with a working force of 1,300 men. The recent reduction in the price from $80 to $65 per flask has not induced any new buying.

Caecilie to Continue. Production will not be suspended at the Caecilie zinc mine of Zinc de Silesie, operating in Upper Silesia. This property, one of the largest zinc-ore producers in Europe, employs about 1,400 men. Discovery of new high-grade ore and the comparative steadiness in London zinc prices recently influenced the company to change its decision. Announcement that the mine would close was made earlier in the month.

London, England, Jan. 23

Trepca Tonnage Up. Trepca Mines, in Yugoslavia, set a new record in December by treating 28,426 metric tons of ore, from which was recovered 3,854 tons of concentrate averaging 76.8 per cent lead and 30.3 oz. of silver per ton, and 4,312 tons of concentrate averaging 50.9 per cent zinc. At the annual meeting in London on Dec. 31, A. Chester Beatty, the chairman, said that after paying its initial dividend Trepca had £95,000 in the bank. Mentioning that ore reserves at the end of September were 2,100,000 tons averaging 10.5 per cent lead and 7.8 per cent zinc, he said: "I have every confidence that between 4,000,000 and 5,000,000 tons will ultimately prove to be contained in the orebody above the horizon of the deep adit level; moreover, we must not forget that we have exposed in the deep level adit a very large body of fine-grade ore with no signs of its giving out."

Contracts have been concluded for sale of zinc concentrate during the next two years, and lead concentrate during the next three years. The pyrite in the ore is being recovered in a product containing about 50 per cent sulphur, and the sale of this is expected to increase revenue. Work on the foundations for a 50 per cent increase of Trepca's mill capacity is well advanced.

Zletovo Proves Reserves. Zletovo Mines, of Yugoslavia, controlled by the Beatty-Selection Trust interests, did 869 m. of driving, crosscutting, and other mining work, and 630 m. of diamond drilling, during 1931 to Sept. 30. This work was confined to No. 1 vein. The general manager estimates partly developed and possible ore at 632,000 metric tons averaging 15.4 per cent lead, 3.1 per cent zinc, and 4.6 oz. of silver per ton. The average width of the vein is 4 ft. 3 in. Continued development is expected to add materially to this tonnage. Only assessment work has been done on the remainder of the company's property. Work on No. 1 vein will continue to the end of April. Funds are being supplied for this purpose. Decision will then be made whether to proceed with a further stage of development or to equip for production.

South Crofty Resumes. As a result of the rise in the price of tin, in terms of depreciated sterling, South Crofty, one of the larger Cornish tin producers, has resumed production, suspended in October, 1930. In December, 1931, the mill treated 4,137 long tons of ore, recovering 51 tons of high-grade concentrate, or about 28 lb. of concentrate per ton. East Pool & Agar is the only other Cornish mine operating.

Tin Stocks Up. Stocks of tin in the hands of the International Tin Pool, formed by leading tin-producing countries to restrict production and hold stocks of the metal, now total 21,000 long tons of fine tin. Estimated production of tin at the new rate, made effective at the beginning of the year, is 110,000 tons annually. This compares with estimated consumption of 120,000 tons annually.

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Production Statistics

Recently published annual reports contain the following figures for production by individual companies. These figures are for the years ended June 30, 1930, and June 30, 1931, except where otherwise indicated.

	1930	1931
Kamunting Tin		**Malay**
Ground dredged, cu.yd.	4,122,000	3,483,000
Tin concentrate, long tons	1,097	1,228
Associated Gold (*a*)		**Australia**
Ore treated, long tons	56,388	62,116
Gold, oz.	28,144	26,583
Ariston Gold (*b*)		**Gold Coast**
Ore treated, long tons	(*c*)	51,626
Gold, dwt. per ton	(*c*)	8.7
Cresson Consolidated (*d*)		**Colorado**
Ore treated, short tons	79,347	80,479
Gold, oz.	32,337	38,385
New Goldfields of Venezuela (*e*)		**Venezuela**
Ore crushed, long tons	(*c*)	64,836
Gold, oz.	(*c*)	26,954
Rangeng Tin (*d*)		**Malay**
Ground dredged, cu.yd.	(*c*)	1,033,000
Tin concentrate, long tons	(*c*)	294
Pioneer Tin		**Australia**
Ground sluiced, cu.yd.	(*c*)	66,800
Tin concentrate, long tons	(*c*)	120
Huelva Copper		**Spain**
Ore extracted, metric tons	49,054	60,805
Copper, tons	2,069	2,202
Mount Morgan		**Australia**
Copper precipitate, long tons	(*c*)	276
Copper content, tons	(*c*)	223
Mines d'Or du Chatelet (*f*)		**France**
Gold, fine oz.	7,128	10,265
Mines de Bor (*f*)		**Yugoslavia**
Copper, metric tons	24,463	24,351
Phosphates du Djebel M'Dilla (*f*)		**Tunis**
Phosphate, metric tons	396,144	326,000
Phosphates de Gafsa (*f*)		**Tunis**
Phosphate shipments, metric tons	1,714,000	1,239,315
Sunshine Mining (*f*)		**Idaho**
Ore milled, short tons	147,948	173,168
Silver, oz.	2,310,000	2,405,840
Lead, tons	773	(*c*)
Ashanti Goldfields (*b*)		**Gold Coast**
Ore milled, long tons	124,200	142,910
Gold, oz.	144,470	169,245
Silver, oz.	8,509	10,441
Penawat (Malaya) Tin (*d*)		**Malaya**
Ground dredged, cu.yd.	(*c*)	2,678,600
Tin concentrate, long tons	828	823

(*a*) For the year ended March 31, 1931
(*b*) For the year ended Sept. 30, 1931
(*c*) Not available
(*d*) For the year ended Aug. 31, 1931
(*e*) For the sixteen months ended June 30, 1931
(*f*) For the year ended Dec. 31, 1931.

CANADA

Sudbury, Ont., Jan. 28

Ontario Gold Output. Bullion produced by Ontario gold mines during 1931 was worth $42,696,453 U. S. currency, an increase of $7,177,591, or about 20 per cent, over 1930. In addition, the mines obtained substantial additional income from premiums paid on bullion received at Ottawa. Kirkland Lake mines produced $21,789,767 from 1,700,885 tons of ore. Porcupine mines produced $19,893,544 from 3,078,609 tons of ore. The remainder came from smaller properties in northwestern Ontario. Gold is also produced as a byproduct of the nickel-copper industry at Sudbury, but these figures are not yet available.

Ashley Will Get Mill. Mining Corporation is considering plans for a new mill for its subsidiary, Ashley Gold Mining, at Bannockburn. The type of plant or capacity has not yet been decided. Northern Ontario Power Company has completed a transmission line to the mine. Electric power will be turned on early in February. The Ontario government has let a contract for cutting a road from the Ashley property to Elk Lake, a distance of about 30 miles.

The shaft has been completed to 500 ft., and two new levels at 375 and 500 ft. have been drifted on for distances of 168 ft. and 127 ft., respectively. Ore developments are officially reported to be as good as, and in some cases better than, those at the 250 level, where one oreshoot yielded an average of $17.83 across 4 ft. for a length of 198 ft. Equipment made available through the closing down of the Corporation's South Lorrain operations and slackening of work at Cobalt has been transferred to the Ashley.

Barry May Re-Finance. A special meeting of stockholders of Barry Hollinger has been called for Feb. 19 to consider financing a new program of shaft sinking, underground development, and expansion of mill facilities. Operated continuously since 1923, this is the only remaining active property in the Boston Creek area, near Kirkland Lake. Recovery during 1931 was about $18,800 a month from treatment of 90 tons of ore daily. Underground development has been carried to a depth of 1,875 ft. Under the proposed reorganization a capitalization of 5,000,000 shares of $1 each would be reduced to 3,000,000 shares and stockholders would receive one new share for two old shares, leaving 800,000 shares available for financing. Tentative development plans call for a new three-compartment shaft from surface to 1,000 ft. and enlargement of the mill from 100 to 300 tons a day.

Dome Enters Pascalis. Dome Mines has acquired an option on a group of claims known as the Jowsey property in the new Pascalis gold area in northwestern Quebec. A program of surface prospecting has been started. Production for 1931 from the Dome Mine at Porcupine was $3,486,505 from 542,000 tons of ore, an average recovery of $6.42 per ton.

Howey Sinks Below 1,000 Ft. Howey Gold, operating at Red Lake, Ont., has started a winze from the 1,000 level to open two new levels at 1,175 ft. and 1,350 ft. At present, 850 tons of ore is mined and hoisted daily, about 750 tons going to the mill after sorting, for a monthly output of about 4,000 oz. The annual report will show broken ore reserves of about 280,000 tons, reported to average about $4 per ton. A small prospecting outfit will be used to extend development. The mine has its own sawmill for making its own timbers.

Inco Output Reduction. On Jan. 1, International Nickel brought all its plants at Sudbury into line with the agreement among world copper producers to restrict production to 26½ per cent of capacity. Actually, the curtailment has had little or no effect on operations, which previously had been reduced to the basis required by the producers. Basic price of nickel for 1932 contracts remains the same as in 1931, according to an official announcement. R. C. Stanley, president, stated that the policy of maintaining a standard price was agreeable to both producer and consumer. January business in nickel, though not as good as November, was if anything better than December.

Ontario Refining, operating the new copper refinery at Copper Cliff, is inviting custom business in handling limited shipments of high-grade gold ores, or in handling gold concentrate or precipitates. Curtailment of copper production by International Nickel, Orco's chief customer, has reduced operations to one anode furnace and one casting furnace working alternately every two weeks. F. Benard is refinery manager.

Macassa Shaft at 1,350 Ft. Macassa Mines has reached a depth of 1,350 ft. in its new three-compartment shaft at Kirkland Lake. Station cutting at the 1,000 level has been completed and sinking resumed with a depth of 2,500 ft. as the objective. At this depth the shaft will connect with a long drive from the workings of Kirkland Lake Gold Mines, the adjoining producer on the east. The drive has been advanced about 1,300 ft. from the east boundary of the property, about 200 ft. of which has been in ore. Lateral diamond drilling has been carried out to explore for parallel ore systems.

Toronto, Ont., Jan. 30

Great Bear Transportation. The suggestion that the Federal government build a motor or tractor road around the rapids of the Bear River in the Great Bear Lake area has received the approval of the Minister of Mines and has been forwarded to the Minister of the Interior for his decision. This action will greatly assist the development of the whole field and would substantially reduce freight rates. In the whole 1,200 miles of water route from the railway to the silver-radium properties at Great Bear Lake there are only two portages, each of 16 miles. Tracks have been laid over the first portage, but the 16 miles of rapids on the Little Bear River flowing out of the Great Bear Lake not only greatly increase costs but cut down the amount of freight being transported at present. With a good motor road around these rapids freight rates could be reduced below $100 a ton.

Operators throughout the district are already considering plans for silver production, because even with the high freight rates and present difficulties of operation, high-grade ore could be shipped out at a profit. Fuel for heat and power could be obtained from the oil wells of Fort Norman, 300 miles away by water transportation.

Lake Shore Record. During the December quarter Lake Shore Mines, at Kirkland Lake, treated 212,650 tons of gold ore and recovered an average of $15.19 a ton, a gross recovery of $3,230,000. The average daily milling rate was 2,362 tons. These figures constitute a new high record for the Lake Shore.

Vancouver, B. C., Jan. 28

Alexandria Mill Considered. Arrangements have been concluded between Alexandria Gold Mines and the International Mining Corporation, of Toronto, for the financing of further operations at the Alexandria Gold mine, on Phillips Arm. Four thousand dollars monthly is to be furnished for development during a period of three months, and the construction of a 100-ton mill is contemplated by an operating company in which the respective parties will be interested on a 50-50 basis. Under this arrangement, this property is expected to start production during the year.

C. M. & S. Output Down. Consolidated Mining & Smelting has issued figures of metal production for 1931.

Mining Company Dividends for January, 1932

Companies in the United States	Situation	Per Share	Total Disbursements
Aluminum Company of America, pfd	Various	$1.50Q	$2,214,930
Bunker Hill & Sullivan, pfd., l, s	Idaho	1.50Q	10,220
Creason Consolidated, g	Colorado	0.01Q	12,000
Granite Gold	Colorado	0.01	16,005
Homestake Mining, g	South Dakota	0.65M	163,254
Kennecott Copper	Various	0.125Q	1,171,516
Magma Copper	Arizona	0.125Q	51,020
Tom Reed Gold Mines	Arizona	0.03Q	60,000
U. S. Smelting, Refining & Mining	Various	0.25Q	121,587
U. S. Smelting, Refining & Mining, pfd	Various	0.875	425,557
Companies in Other Countries			
Consolidated M. & S.	Canada	1.25SAS	176,088
Dome Mines, g	Canada	0.25Q	238,333
Hollinger Consolidated Gold	Canada	0.05M	246,000
Howe Sound, c, l, z	Canada, Mexico	0.50Q	248,020
Lucky Tiger-Combination Gold, s	Mexico	0.03Q	21,460
New York & Honduras Rosario, s, g	Honduras	0.375QX	75,000
Pioneer Gold	Canada	0.03Q	50,000
Premier Gold	Canada	0.03Q	150,000
Wright-Hargreaves, g	Canada	0.05QX	275,000
Total			$5,725,990

c, copper; s, silver; l, lead; g, gold; z, zinc; Q, quarterly; M, monthly; SAS, semi-annual, includes 5 per cent stock dividend; X, extra.

Lead output dropped from 151,492 tons to 138,843 tons; zinc, from 119,550 tons to 101,124 tons; copper, from 7,064 tons to 607 tons; gold showed a decline of only 814 oz. to 24,968 oz., and silver production was 6,572,119 oz., as compared with 6,936,759 oz. in 1930. The company is steadily expanding its market for fertilizers from its new plant at Warfield. A first consignment of 200 tons of sulphate of ammonia was made recently to China, and shipments are also being made to Hawaii and the Dutch East Indies.

Renewed Interest at Jewel. Recent discoveries of a high-grade telluride ore on the Gold Drop property, in the Jewel camp, near Greenwood, have stimulated considerable activity in this area. The old Jewel mine is expected to reopen, and an active campaign of development is outlined upon the series of gold-quartz veins, of which the Jewel vein produced about 30,000 tons of ore valued at $10 per ton several years ago.

Lorne Mill Ready. Construction of the new 100-ton mill at the Lorne gold mine, in the Bridge River district, has been completed and the machinery is being tuned up.

Yankee Girl Reopened. The Yankee Girl mine, at Ymir, has been leased by interests represented by E. P. Crawford, who was identified formerly with the development of the property. This gold property was absorbed by promotion interests represented by Stobie Forlong & Company, and a heavy expense was incurred in carrying out some ambitious work intended to develop the orebodies at considerable depth, but which never reached its objective. Present plans are restricted to stoping operations and to shipping ore to the Trail smelter with the prospect of the erection of a small mill.

Wellington Adds to Reserves. Progress of development at the Wellington mine, on Wallace Mountain, Kettle valley district, was disclosed at the annual meeting of the Wellington Beaverdell Mines, held recently in Greenwood. Considerable reserves of ore are blocked out, and several shipments from development headings have been made to the Trail smelter during the year. The mine is considered to be in good condition to take advantage of any rise in the price of silver. Another shaft will be sunk from the No. 5 level.

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RUSSIA

London, England, Jan. 17

Soviet Buys Tetiuhe. By purchase of the Tetiuhe concession, in eastern Siberia, the Soviet government has regained possession of all the metal mines in Russia. The purchase price of £940,000 will be paid in eighteen annual installments, without interest, beginning this year. A. Chester Beatty, chairman of Tetiuhe Mining, says it was a transaction between a willing buyer and a willing seller. The Tetiuhe property was confiscated in the Revolution, but the former operating company obtained a concession, and the present company was formed in 1925. During the year ended Sept. 30, 1930, output was 13,376 metric tons of lead concentrate and 28,396 tons of zinc concentrate from 135,955 tons milled. A lead smelter started operation last October.

The great distance of the property from markets, the fall in the prices of zinc, lead, and silver, and a change in the policy of the Soviet government made operations unprofitable. In view of this change of policy Mr. Beatty suggested that the Soviet government purchase the concession and equipment at a valuation to be agreed upon by its technical representatives and those of the company. This proposition was accepted. The purchase price is expected to retire the debenture issue and eventually return approximately the par value of the outstanding stock.

New York, N. Y., Jan. 27

Kounrad Copper Reserves. The ore reserves at the Kounrad copper properties, near Lake Balkhash, Kazak, U.S.S.R., contain 1,500,000 tons of copper in ore that averages 1.2 per cent copper, according to V. M. Karmashov, writing in *Metal Progress.* A concentrator is now under construction that will have a daily capacity of 50,000 tons of ore. The smelter will be equipped to produce 200,000 tons of copper annually and is expected to start in 1933. About 300 miles of a 550-mile railroad from Petropavlovsk, on the Trans-Siberian railroad, has been completed. The cost of the railroad and of equipping the mines is estimated at about $250,000,000. This indicates a capital charge of over $150 per ton of copper developed, unless additional ore is developed or other sources of freight for the railroad are found. The country surrounding Lake Balkhash is entirely barren.

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PHILIPPINE ISLANDS

San Francisco, Calif., Jan. 11

Benguet Reserves Up. A large increase in Benguet Consolidated's ore reserves at its property near Baguio, P. I., has resulted from the discovery of a new vein known as the 320 West. On Dec. 31, 1931, total ore reserves were estimated at 467,600 tons averaging $15.03 in gold per ton. Of this 226,600 tons was positive and 240,990 tons was probable. On Dec. 31, 1930, reserves were 209,040 tons of positive ore averaging $11.89 and 133,310 tons of probable ore averaging $12.67. Production of ore continues to be about 300 tons daily, but as the grade has improved, monthly output is up to $155,000, compared with an average of $138,000 throughout 1931.

The new 320 West Vein has been followed for at least 380 ft. on the 300 level. In addition a raise 110 ft. high has been put up and a winze has gone down 10 ft. Indicated average width in these workings is about 25 ft. and the grade is $25 per ton. The face of the drift, at last report, had 400 ft. to go to reach the point where ore was first discovered by drilling from the surface. Development is proceeding in other sections of the workings. In November, the total footage was 3,332 ft., or more than 100 ft. per day. As the 1931 year-end ore position represents an improvement of 125,000 tons in volume and $3,280,000 in value over 1930, the life of the mine has been materially increased.

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AUSTRALIA

Melbourne, Victoria, Dec. 21

Adelong Plans to Sell Dredge. Shareholders of Adelong Gold Estates were informed by E. H. Shackell, at the half-yearly meeting recently, that the gold-dredging plant at Adelong, N. S. W., had been held together as a complete unit, with a view to disposal. The revival in the gold-mining industry encouraged the belief that the dredge would eventually be sold to advantage. No mining or treatment operations had been carried out by tributers at the South Comet mine, in Tasmania, because of the unremunerative prices ruling for lead and silver. The recent advance in the London price of these metals, and a concession in the rates of royalty payment, have induced the tributers to resume treatment work at the mill. Future activities at this center depended almost entirely upon the trend of the base-metal market.

Bendigo Gold Output. In eleven months of 1931 prospectors on the Bendigo field have won 5,226 oz. of gold, valued at £31,000, including exchange but excluding the bonus. The gold won by the companies for the same period is 8,892 oz., the principal contributors being Ironbark, 3,397 oz.; Hercules, 2,462 oz.; and New Red, White & Blue, 2,041 oz. Ironbark has paid three dividends this year, and the improved yields at New Red, White & Blue have enabled the company to wipe out its overdraft. It is interesting to note that Australian gold is now worth £7 17s. 7d. per ounce.

Drill Hargraves Field for Gold. After twenty years of idleness, an attempt is to be made to open up the Hargraves gold field, in New South Wales. An area of 135 acres has been taken up by George A. More, mining engineer. The Hargraves field is very similar to Bendigo—the reefs are saddle formations and occur in Ordovician slates. Broken Hill Proprietary has taken up 250 acres of auriferous country near Cowra, N. S .W., and will start diamond drilling immediately to test the large, low-grade orebodies.

Mount Coolon Progress. Mount Coolon Gold Mines is pushing ahead rapidly with the development of its mines and the installation of a 200-ton cyanide mill and power plant at Mount Coolon, in north Queensland. The mine shaft is being stripped and timbered and the power house foundations have been completed. To provide adequate water storage, a dam is being built. Crushing is scheduled to start in September, 1932.

Mount Isa Opens Rio Grande Ore. The development of the Rio Grande lode of Mount Isa, in northern Queensland, will soon be completed and stoping will then commence. This lead-silver

lode is the richest on the field, though only 16 ft. wide. The electric hoist at the Lawlor shaft has been placed in commission. Excavations have started for the erection of two blast furnaces and the necessary blast-roasting equipment. Dumps of rich ore in the vicinity of the Rio Grande shaft are being milled to augment bullion output.

Mount Lyell Grade Dropping. Colin Templeton, chairman of Mount Lyell, copper producer on the west coast of Tasmania, at the annual meeting on Dec. 11 stated that during the last six years the company's extensive development policy had necessitated the expenditure of £452,000. During the last three years the grade of ore mined has dropped from 5.88 per cent to 3.77 per cent copper. For development of the Lyell Comstock, Crown Lyell, and Royal Tharsis orebodies the company has set aside £25,000. Work includes sinking the Lyell Comstock shaft below No. 4 level and connecting the Crown Lyell workings with the North Lyell tunnel. The Crown Lyell contains about 500,000 tons of low-grade ore above the 500 level. Another deposit, the Lyell Tharsis, not now being worked, is expected to yield 1,000,000 tons of 1.5 per cent copper ore, most of which can be extracted by open-cutting.

Since issuing its annual report the company has placed in commission the new coarse-crushing section. From two 500-ton steel bins the ore gravitates over 3-in. grizzlies to a 16-in. Telsmith crusher, which reduces to 3½ in. The crushed ore is conveyed to a Hummer screen provided with 2½-in. aperture openings, 24 sq.ft. in area. Oversize is dropped to a 5½-ft. Symons cone crusher crushing to ⅝ in. The Symons crusher discharge and the undersize of the Hummer screen are received by two 6x3-ft. Leahy screens fitted with ¾-in. mesh. A 4-ft. Symons crusher then receives the oversize and crushes to ½ in. The discharge passes to crushed-ore bins that serve the Marcy ball mills in the grinding section.

Mount Morgan Tests Ore. The Mount Morgan Company, a new organization formed to obtain copper by underground leaching at the famous Mount Morgan mine, reports a loss of £4,435 for the year ended June 30. A total of 185,000,000 gal. of water was pumped from underground for a production of 276 tons of copper precipitate containing 223 tons of metallic copper. The company recently dispatched to Mount Isa a trial parcel of 30 tons of gold-copper ore obtained from the open cut at the Linda level. There are 660,000 tons available for extraction. With the present price of gold in Australian currency, this ore will yield a profit of 6s. 4d. per ton when treated at the rate of 3,000 tons weekly. This would give employment at Mount Morgan for 300 men.

Palmer River Loss. Because of the necessity of adding equipment to its dredge, on the Palmer River, in northern Queensland, Palmer River Dredging reports a loss of £852 in the fiscal year ended Aug. 31. Production started in February. Output totaled 819 oz. of gold. The operation is of interest because it is the first gold dredge to operate in Queensland for several years. Costs are down to 4.9d. per cubic yard.

Kalgoorlie, W. A., Dec. 22

British Finance New Work. British capital has been secured for the Tindals, Big Bell, and Edjudina gold mines by Herman Mandelstamm. Mr. Mandelstamm has been negotiating for many months to secure this capital, and advice has been received that he has been successful and that he will leave London early next January. The Big Bell mine is near Cue, and encouraging results have been obtained from drilling. Six holes have been put down. Big Bell was once described as Western Australia's longest and widest gold-bearing formation, but has never been worked to any extent. In 1928 the property was acquired for London investors.

Tindals mine is near Coolgardie and was once regarded as the best low-grade proposition on the eastern gold fields. For years it was worked by a Melbourne company. Since 1929, four holes have been put down and passed through payable oreshoots. The deepest was at 538 ft.

The Edjudina mines are in the North Coolgardie district and have already yielded 50,000 oz. of gold. These mines will be further tested by diamond drilling. The reopening of Tindals, at Coolgardie, is expected to bring a revival in this area, as several outside companies have taken options over leases in the district. The Broken Hill Proprietary company has also tested several showings of gold in the vicinity.

November Gold Output High. Increased activity in gold mining continues in Western Australia, stimulated by the increased price of gold in London, the premium resulting from the rate of exchange and the gold bonus. In November, 53,869 oz. was produced, which is the highest production for November since 1920. The average number of men employed in the industry is 6,623, an increase of 690 in three months, and 2,098 more than at the beginning of the year. State-operated batteries in the last twelve months have increased in number from 21 to 33. A new battery will be opened on the old Iron Duke lease, Kalgoorlie, early in the new year.

Mines Rotate Holidays. As the result of the introduction of a system of rotation of holidays, instead of the annual fortnightly closure of all mines at the end of the year, all mines on the Golden Mile, Kalgoorlie, with the exception of Great Boulder Proprietary, will continue working. This new system is expected to save several thousand pounds, as there will be no suspension of operations.

London, England, Jan. 20

Wiluna Development Work. On the 450 level, the east crosscut south of the shaft has cut an orebody assaying 35s. in gold per ton over a width of 36 in. about 150 ft. east of the East Lode at the Wiluna Gold property, near Meekatharra, Western Australia, according to John A. Agnew, director of the company, at the annual meeting on Dec. 30. In addition, diamond drilling has indicated ore 110 ft. west of the West Lode. Although development for the next two months will be confined largely to the two main orebodies on the 625 and 800 levels, exploration of these new showings will be undertaken.

NEW ZEALAND

Melbourne, Australia, Dec. 21

Gold Output May Rise. Gold output in New Zealand has for many years been about 125,000 oz. annually, most of which has been produced by Waihi Gold. The world-wide depression has been responsible for a marked increase in prospecting and development in New Zealand, and if but a few of the mines now being worked prove satisfactory, the output of gold should be greatly augmented. The large steel dredge of Rimu at Hokitika has been placed in commission, taking the place of the wooden dredge which during the last ten years treated at a substantial profit 16,000,000 cu.yd., yielding 15c. per yard.

Blackwater Mines at Reefton, which made a profit of £9,716 during 1930 on an output of £70,095, has 84,000 tons assaying 9.6 dwt. per ton in reserve and is taking steps to increase its output. The Gold Progress, Central Otago, cleaned up, for its first crushing, 328 oz. of retorted gold from 208 tons, and a highly profitable future is forecast. After many years of idleness, Waiomo Sulphide, Thames, has resumed operations. A trial crushing showed ore on the footwall at No. 1 level.

■

ASIA

Bombay, India, Jan. 16

Gold Shipments to England. Associated Press dispatches from here state that in the four months since Great Britain abandoned the gold standard, more than $100,000,000 worth of gold (or about 5,000,000 oz.) has been shipped to England. If shipments continue at the present rate, they will equal current production of gold of about 21,000,000 oz. annually. The gold being shipped is not monetary gold but represents hoarded coins and jewelry which are being purchased from the peasants by the bullion merchants. The existence of a premium on gold, as the result of the depreciation of the rupee, makes the peasants more anxious to sell. Mahatma Gandhi, Nationalist leader in India, has appealed to the people not to exchange their gold for depreciated paper currency.

London, England, Jan. 23

Penawat (Malaya) Curtailed. During the fiscal year ended Aug. 31, Penawat (Malaya) Tin Dredging, which operates two dredges in the Kinta district, Perak, F.M.S., produced at about 70 per cent of capacity. Each of the dredges has a capacity of 2,000,000 cu.yd. of gravel annually. The average price realized was £71 per ton of concentrate, compared with £101 the previous year. Grade of concentrate was 75.37 per cent tin.

Burma Corporation Output. Operations at Burma Corporation are now at about 65 per cent of capacity, the monthly report for December indicates. The tonnage mined was 28,532 long tons, and the mill handled 24,400 tons compared with capacity of 40,000 tons. Production of all metals is lower, refined lead output being 5,880 tons and silver, 470,000 oz. Development on the Nos. 3 and 4 levels of the Meingtha orebodies continues to show ore averaging more than 20 per cent lead.

Copper Price Weakens in Dull Market—Zinc at New Low—Lead Steady

January came to a close with no tangible improvement in business, with the result that copper and zinc prices developed renewed weakness, the latter falling to the lowest level on record. Lead prices were well maintained throughout the month. Both tin and silver fluctuated within narrow limits in a rather uninteresting market. Antimony strengthened toward the close on fears that shipments from China may be delayed because of the political developments in the Far East. Low prices are restricting domestic production of quicksilver. The *E.&M.J.* index of non-ferrous metal prices for the month of January, 1932, was 54.87, against 53.77 in December, 1931, and 67.62 in January of last year. The moderate uplift in the index number that took place in January was brought about by the higher market for copper that prevailed almost to the close of the month.

Selling Pressure in Copper

The market for copper held up pretty well until the last week of the month, when custom smelters became uneasy over the absence of foreign and domestic buying. Export demand during January was not sufficient in volume to absorb the moderate offerings from this source. The new rules of the export association extend priority to custom smelter copper, but, so far as can be learned, the sales allotted to this group fell far short of expectations. Custom smelters came out openly toward the close of the period with offerings of the metal at 6¾c., Connecticut basis. (In the first week of February, the current month, copper actually sold down to 6½c.) Total sales of copper in the domestic market during the first month of the new year were very small. In the second week of the period the market showed a little life on official announcement that the revised export rules had been approved by all concerned in the matter, and the price, as a result of this statement, was moved up to a 7½c. Connecticut basis.

Statistics on copper for general distribution are still being withheld, but few in intimate touch with the industry hold any false notions as to the true position of the market. Operators are of one mind regarding the current rate of consumption, and there is little or no doubt that world production under the present agreement is in excess of requirements. This, of course, is the reason back of the weakness that has again forced prices downward.

Sales for export during January totaled 16,354 long tons, against 25,450 long tons in December. The official export price was raised from 7½c. to 7⅝c., c.i.f. basis on Jan. 12. Custom smelters offered copper at 7⅛c. to European buyers on Jan. 29, under the new regulations, but this failed to bring out much business. (On Feb. 2 the official price was dropped from 7⅝c. to 6⅞c., c.i.f. basis.)

Interest in a copper tariff has shifted from this country to England. Talk of a general tariff on imports into the United Kingdom has disturbed producers. An English tariff on copper would leave the status of the export plan somewhat in doubt.

Lead Price Holds

Sales of virgin lead for January shipment to domestic consumers were not far under the average of recent months, amounting to about 29,000 tons. With production holding at about the same level as in December, prices were fairly well maintained. The market in New York settled at 3.75c., the contract basis of the A.S.&R., and St. Louis quoted 3.55c. The unsettlement in copper and zinc naturally had some influence on the market, especially toward the close of the month, as demand fell off appreciably.

Stocks of recoverable lead in the U. S. Jan. 1 totaled 217,716 tons, against 210,434 tons on Dec. 1, according to the American Bureau of Metal Statistics. Figures for January on refined lead are expected to show a moderate increase in stocks.

World production of lead during December held at about the same rate as in November. December production was 122,691 tons, against 119,398 tons in November, according to the American Bureau of Metal Statistics. The daily rate for December was 3,958 tons, against 3,980 tons in the preceding month.

Lead production in 1931 totaled 1,512,155 tons, the Bureau reports, against 1,833,281 tons in 1930.

Production figures for October, November, and December, 1931, in short tons, follow:

	Oct.	Nov.	Dec.
United States	36,456	31,671	33,576
Canada	10,537	10,391	11,083
Mexico	17,886	18,806	17,624
Germany	10,567	8,057 (c)	9,300
Italy	2,679	2,617	2,449
Spain and Tunis (a)	6,336	7,549	7,763
Europe (b)	13,900	15,600	16,000
Australia	10,135	15,837	15,926
Burma	6,698	6,670	6,670
Elsewhere (c)	2,700	2,200	2,300
Totals	117,984	119,398	122,691

(a) Partial. (b) Estimated and not specified elsewhere. (c) Estimated.

Zinc Under 3c.

Disappointment over the continued slow movement of zinc into consumptive channels brought out pressure to sell from more than one direction. The month opened with Prime Western zinc at 3.075c., St. Louis, and closed at 2.825c., prompt shipment metal, a new all-time low. The previous low was 2.90c. in February, 1895. In some quarters of the market it is held that further curtailment in output is necessary to keep stocks from increasing, even though domestic production now is down to about 20,000 tons a month. The decline in the price to below 3c. per pound, St. Louis, according to observers, will probably force a number of producers to shut down completely.

Current Statistics of Production and Stocks of Copper, Lead, and Zinc

Data from American Bureau of Metal Statistics, American Zinc Institute, and Metallgesellschaft

All Figures Except Tin Represent Tons of 2,000 Lb.

	1931											
COPPER — North and South America	Jan.	Feb.	March	April	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.
Production, refined, daily average	3,305	3,566	2,292	3,350	3,313	3,276	3,110	2,909	2,890	.....	.....	.....
Domestic shipments	60,209	60,636	75,685	54,567	45,265	50,217	43,144	45,816	40,459	.....	.....	.....
Foreign shipments	45,597	39,415	36,797	32,218	26,684	33,251	26,321	29,016	22,124	.....	.....	.....
Stocks, blister and refined	574,464	566,853	553,016	561,797	589,245	600,827	620,075	631,880	658,321	.....	.....	.....
LEAD — United States												
Production, refined, from domestic ore	43,405	39,464	41,775	35,498	39,519	30,708	32,157	34,144	31,966	36,546	31,671	33,576
Production, secondary and foreign	3,892	4,654	3,025	2,941	3,598	3,683	4,409	5,453	3,934	4,722	3,820	4,031
Production, total, daily rate	1,526	1,575	1,448	1,280	1,390	1,146	1,179	1,151	1,163	1,331	1,180	1,213
Shipments reported	37,633	34,439	36,761	35,324	34,081	37,054	42,219	38,590	38,059	34,276	31,216	30,297
Stocks, end of month	113,145	122,826	130,426	132,993	142,370	139,698	133,958	134,977	132,804	139,796	144,057	151,380
ZINC — United States												
Production, daily average	1,049	1,056	1,043	971	971	783	689	692	712	699	684	709
Domestic shipments	31,022	30,249	35,224	27,418	25,831	27,604	28,460	23,599	20,902	21,163	20,327	23,005
Export shipments	.....	.....	.....	.....	20	.....	20	.....	.....	.....	.....	.....
Stocks, end of month	145,176	144,389	141,493	143,212	143,049	138,928	131,833	129,701	130,155	130,666	130,865	129,825
World Production Rate (Daily Average)												
Copper	4,174	4,596	4,418	4,296	4,209	4,224	3,919	3,924	4,023	.....	.....	.....
Lead	4,694	4,883	4,693	4,898	3,988	3,995	3,691	3,906	3,654	3,806	3,980	3,958
Zinc	3,678	3,721	3,574	3,429	3,212	3,127	2,860	2,766	2,815	2,740	2,728	2,604
Tin (Metric Tons)	439	1504	436	426	419	418	425	401	348	352	347	.....

Tin Unchanged

United States deliveries of tin during January were estimated at 3,550 tons, against 3,380 long tons in December. Actual consumption of tin in the United States is believed to be somewhat in excess of these figures. Consumers accumulated some metal during 1931, and part of this excess is now moving into consumption. With production greatly curtailed, and producers apparently willing to make further sacrifices, selling pressure in tin has not been in evidence. The tin pool is accumulating supplies, indicating that the group has confidence in the outlook. During the month of January the price movement in tin has been narrow, the final quotation showing virtually no change, compared with the opening price.

Silver Unsettled

Increased offerings of silver from China served to unsettle prices, and the market during January was a little lower than in the preceding month. Speculative interest was not so pronounced, owing chiefly to the unfavorable news from China and India.

Lead and Zinc Concentrates

Galena, basis 80 per cent lead, settled at $37.50 to $42.50 per ton, the outside figure being a little higher than that named a month ago. Stocks of lead ore at Joplin declined from 21,900 tons to about 18,000 tons during January.

Blende eased off in price in sympathy with the market for the metal. Prime zinc concentrate, basis 60 per cent, closed the month at $17 per ton, though an attempt was made to lower the quotation to $16.

Other Metals

Quotations cover wholesale lots, f.o.b. New York, unless otherwise specified. London prices are according to latest mail advices, and at present are largely nominal in view of erratic sterling exchange.

ALUMINUM—Per lb., delivered, Alcoa commercial and mill ingot, 99 and 98 per cent, 23.30c.; Alcoa No. 12 alloy, 22c.; metallurgical ingot, 94 per cent plus, 23.30c.; 98@99 per cent, 22.90c. London, £95, less 2 per cent, per long ton, for 98 per cent ingots and bars.

ANTIMONY—Per lb., duty paid. Chinese, spot, 5.95c.; futures, nominal on uncertainty over Japanese situation.

BERYLLIUM—See Alloys.

BISMUTH—Per lb., in ton lots, 85c. London (dollar basis), 75c.

CADMIUM—Per lb., 55c. London, 2s. 5d. to 2s. 6d. Nominal.

CHROMIUM—Per lb., 97@98 per cent grade, 85@90c. per lb. contained chromium, maximum 1 or 2 per cent iron. (Usually sold as ferrochrome.)

COBALT—Per lb.: Metal imported from Belgium, 97@99 per cent, $2.50 less 35 per cent for cash. On yearly requirements, usual rebate of 5 to 10 per cent, as to quantity. London quotes $3.65 per kilo, subject to usual discounts.

INDIUM—Per oz., 98½ per cent, $90@$100 per oz. Nominal.

IRIDIUM—Per oz., $90@$100 for 98@99 per cent sponge and powder. London, £24@£26. Nominal.

LITHIUM—Per lb., 98@99 per cent, 100-lb. lots, $15.

MAGNESIUM—Per lb., ingots (4x16 in.), 99½ per cent, 30c. in carloads; 32c. in 100 lb. lots or more, l.c.l.; ⅜, ½, 1, and 2 lb. sticks, 5c. per lb. over ingot price; ¼ and ½ lb. sticks, 8c. per lb. extra.

MANGANESE—Per lb., 95@97 per cent, 42c. (Usually sold as ferromanganese.)

MOLYBDENUM—Per lb., in 10- to 50-lb. lots, C.P. powder, $9; 97 per cent, $4.50. (Usually sold as calcium molybdate or ferromolybdenum, which see.)

NICKEL—Per lb. electrolytic cathodes, 35c.; shot and ingot made from remelted electro, 36c. for single lots of spot metal. London, per long ton, £245 to £250, with prices nominal.

OSMIUM—Per oz., $65@$70. London, £20 10s. to £21.

PALLADIUM—Per oz., $19@$21. London, £5 10s., nominal.

PLATINUM—Per oz. Official price of leading interest, $40. Cash transactions between dealers and refiners several dollars less. London market nominal at £11 to £11 6d. The average price of Colombian crude, basis 85 per cent platinum, for December was $29.75 per oz.

QUICKSILVER—Per 76-lb. flask, $64@$65. Market dull.

RADIUM—Per mg. radium content, $50 in lots of 4 grams or more, to $65 for 1 gram; smaller quantities, $70.

RHODIUM—Per oz., $55@$60.

RUTHENIUM—Per oz., $50@$55.

SELENIUM—Per lb., $1.80@$2, depending on quantity, for black, powdered, 99.5 per cent pure.

SILICON—Per lb., minimum 97 per cent Si, maximum 1 per cent Fe, 15@17c.

TANTALUM—Per kilo, $91 for C.P. bar or sheet.

TELLURIUM—Per lb., $2.

THALLIUM—Per lb., $12.50@$15.

TITANIUM—Per lb. in 50- to 100-lb. lots, 75 per cent, $5.

TUNGSTEN—Per lb., contained tungsten, 98 per cent, powdered, $1.45.

Average Metal Prices for January, 1932

COPPER:	
Electrolytic, refinery	7.060
London Standard, Spot	39.459
London Electrolytic, Bid	46.200
LEAD:	
New York	3.750
St. Louis	3.550
London Spot	15.084
London Forward	15.128
SILVER:	
New York	29.780
London	19.623
Sterling Exchange	342.515
ZINC:	
St. Louis	3.011
London Spot	14.416
London Forward	14.834
TIN:	
Straits	21.804
London Standard Spot	140.219
QUICKSILVER	64.900
ANTIMONY	5.976
PLATINUM, Refined	40.000
CADMIUM	55.000
ALUMINUM, 99 Per Cent Plus	23.300

Metallic Ores

Prices in tons of 2,000 lb., or in "units" of 20 lb., unless otherwise stated.

ANTIMONY ORE—No sales reported. London, per long ton unit, 4s. 6d. for 60 to 65 per cent sulphide ore.

BERYLLIUM ORE—Per ton, minimum 10 per cent BeO, $20@$30, f.o.b. mines.

CHROME ORE—Per long ton, c.i.f. Atlantic ports, Indian ores, $17.50 for 48@50 per cent Cr_2O_3 ore, and $19.50@$20 for 50@51 per cent ore. London, 80s. for 48 per cent Rhodesian.

COBALT ORE—Per lb. of Co, 12 to 14 per cent grade, 50c., f.o.b. cars, Ontario. Market nominal.

IRON ORE—Per long ton, Lower Lake ports. Lake Superior ores:

Mesabi, non-bessemer, 51½ per cent iron, $4.50. Old Range, non-bessemer, $4.65.

Mesabi, bessemer, 51½ per cent iron, $4.65. Old Range, bessemer, 51½ per cent, $4.80.

Eastern ores, cents per long ton unit, delivered at furnaces: Foundry and basic, 56 to 63 per cent, 10c.

Foreign ores, alongside docks Atlantic ports, cargo lots, cents per long ton unit:

North African and Swedish, low-phosphorus, 8@9c.

Spanish and North African, basic, 56@60 per cent, 7@8½c.

Swedish foundry or basic, 65@68 per cent, 8c.

Newfoundland foundry, 55 per cent iron, 8c. Nominal.

MANGANESE ORE—Per long ton unit of Mn, c.i.f. North Atlantic ports, cargo lots, exclusive of duty: Brazilian, 46@48 per cent Mn, 23c.; Chilean, 47 per cent minimum, 29c.; Indian, 48@50 per cent, 25@26c.; Caucasian, 52@55 per cent, 26c.; South African, 52@54 per cent, 23@24c.; 50 to 52 per cent, 22@24c.; 44 to 46 per cent, 21c.

Per ton in carload lots:

Chemical grades, powdered, coarse or fine, minimum 80 per cent MnO_2, Brazilian or Cuban, $50 in carloads, to $60 barreled. Javan or Caucasian, 85 per cent minimum, $50@$60. Domes-

tic, 70 to 72 per cent, $43@$50 in carloads, f.o.b. mines.

MOLYBDENUM ORE—Per lb. of contained MoS_2, nominally 45c., delivered Pittsburgh, for 75@85 per cent concentrate. London, per long ton unit, nominal at 37s. to 38s. for 80@85 per cent concentrate.

TANTALUM ORE—Per lb., Ta_2O_5, 70c. for 60 per cent ore. Market nominal.

TIN ORE — No market in United States. London quotes £9 10s. to £9 15s. per ton returning charges on 60 per cent Bolivian ore.

TITANIUM ORE — Per gross ton, ilmenite, 45@52 per cent TiO_2, f.o.b. Atlantic seaboard, $10@$12, according to grade and impurities. Low-grade domestic, 32 to 35 per cent, about $7 @$8. Rutile, per lb., guaranteed minimum 94 per cent concentrate, 10c.

TUNGSTEN ORE—Per unit of WO_3, N. Y.: Chinese wolframite, $10.75@ $11, duty paid. Bolivian scheelite, $10.75. Domestic, $10.50@$11.50.

VANADIUM ORE—Per lb. V_2O_5 contained, 27c., f.o.b. shipping point.

ZIRCON ORE—Per ton, 55 per cent ZrO_2, f.o.b. Atlantic seaboard, $40@$45 in 30-ton lots. Crude granular zircon, $70, f.o.b. Suspension Bridge, N. Y.; milled, $90.

Non-Metallic Minerals

Prices received for non-metallic minerals vary widely and depend upon the physical and chemical characteristics of the commodity. Hence the following quotations can serve only as a general guide to the prices obtained by producers and dealers in different parts of the United States for their own product. In the last analysis the value of a particular non-metallic mineral can be ascertained only by direct negotiation between buyer and seller.

Tons of 2,000 lb. unless otherwise noted.

AMBLYGONITE — Per ton, f.o.b. mines, 8@9 per cent Li_2O, $50@$60.

ASBESTOS — Per ton, f.o.b. Quebec mines, tax and bags included: Crude No. 1, $400 (nominal); crude No. 2, $200; spinning fibers, $80@$125; magnesia and compressed sheet fibers, $100@$125; various grades shingle stock, $50@$65; various grades paper stock, $27.50@$35; cement stock, $15@$20; floats, $10@$15.

Per ton c.i.f. New York: Rhodesian crude No. 1, $300; No. 2, $200. Nominal.

Per ton, c.i.f. New York: Russian crude No. 1, $225; No. 2, $175; No. 3, $125. Nominal.

Per ton, f.o.b. mines, Vermont: Shingle stock, $45; paper stock, $35; cement stock, $20.

BARIUM CARBONATE (Witherite) — Per ton, 90 per cent 300 mesh, $42; 100 mesh, $39.

BARYTES—F.o.b. mines:

California: Crude, $7 per ton.

Georgia: Barytes ore, crude, $6@ $6.50 per long ton.

Missouri: Per ton, water ground and floated, bleached, $23, car lots, f.o.b. works. Crude ore, minimum 95 per cent $BaSO_4$, less than 1 per cent iron, $6; 1 per cent iron and 93 per cent $BaSO_4$, $5.50; low-grade, $4.50, f.o.b. mines.

BAUXITE—Per long ton: Domestic ore, chemical, crushed and dried, 55 to 58 per cent Al_2O_3, 1.5 to 2.5 per cent Fe_2O_3, $6.50@$8, f.o.b. *Alabama* and *Arkansas* mines. Other grades, 56 to 59 per cent Al_2O_3, 5 to 8 per cent SiO_2, $6@$7.50, f.o.b. *Arkansas* mines. Pulverized and dried, 56 to 59 per cent Al_2O_3, 8 to 12 per cent SiO_2, $10@ $12.25, f.o.b. *Arkansas* mines; abrasive grade, crushed and calcined, 78 to 84 per cent Al_2O_3, $14@$16, f.o.b. *Arkansas* mines.

Per metric ton, foreign, c.i.f. Atlantic ports: Dalmatian, 50 to 55 per cent Al_2O_3, 1 to 3 per cent SiO_2, $4.50@ $6. Istrian, 54 to 57 per cent Al_2O_3, 3 to 5 per cent SiO_2, $5.50@$6.50; French, 56 to 59 per cent Al_2O_3, 2 to 4 per cent SiO_2, $5.50@$7.

BENTONITE—Per ton, carload lots, f.o.b. *Wyoming* mines, dried and crushed, in bulk, $8; in bags, $10. F.o.b. Chicago, selected air-floated, $25.

BORAX — Per ton, carload lots, in bags, crystals, $56; granulated, $50; powdered, $57.50; f.o.b. shipping point.

[1]CELESTITE—Per ton in carload lots, 90 per cent $SrSO_4$, finely powdered, $27.

CHINA CLAY (Kaolin)—Per ton, f.o.b. *South Carolina* mines, crude lump, No. 1, $4@$5; crushed, $6.90; pulverized, $9@$15.

Florida, washed and crushed, No. 1, $12.50; No. 2, $12.

Delaware, No. 1, $14.50.

Imported English, f.o.b. American ports: lump, $17@$21 in bulk.

DIATOMITE—Per ton, f.o.b. *Nevada,* crude, dried, in bags, $10; minus 40 mesh, $15; 300 mesh, $20; high temperature insulation, $30.

EMERY—Per ton, f.o.b. *New York,* domestic crude ore, first grade, $10. Other American ore, delivered to grinders, per gross ton, $16; Turkish and Naxos ore, $30@$35. F.o.b. *Pennsylvania,* in 350-lb. kegs, Turkish, Khasia, and Naxos grain emery, 6½c. per lb.; American, 3½c.

FELDSPAR — Per ton, f.o.b. *North Carolina,* potash feldspar, 200 mesh, white, $15, in bulk; soda feldspar, $18. F.o.b. *Maine,* potash feldspar, white, 200 mesh, $19, in bulk. Granular glasspar, white, 20 mesh, f.o.b. *North Carolina,* $10.50 in bulk.

Virginia, No. 1, 325 mesh, $17; 200 mesh, $15@$16; 160 mesh, $14@$15; No. 1 glassmakers', $11; enamelers', $12.50.

New Mexico: Crude clean No. 1 potash spar, $4.75; ground, $9.50.

FLUORSPAR—Per net ton, 85 per cent CaF_2, and not over 5 per cent SiO_2. *Kentucky* and *Illinois* mines, contract, freight allowed Pittsburgh basis: Washed gravel, $20.31; No. 2 lump, $22.31.

Ground fluorspar, f.o.b. *Illinois* mines, 95 to 98 per cent CaF_2 and not over 2½ per cent SiO_2, $30 in bulk; $34 in bags or barrels.

F.o.b. *Colorado* mines, 82-5, $10.

Foreign fluorspar, gravel, 85-5, $18@ $19 per gross ton, duty paid.

FULLER'S EARTH — Per ton, f.o.b. *Colorado,* $18, various finenesses to minus 90 mesh.

F.o.b. *Georgia* or *Florida,* 30 to 60 mesh, $16; 15 to 30, $15; 200 up, $10; 100 up, $7.

GARNET—Per ton, f.o.b. *New Hampshire* mines; concentrate, $40; washed grades, $125.

New York: Adirondack garnet concentrates, $85.

Spanish grades, $60, c.i.f. port of entry.

GILSONITE — Per ton, carload lots, f.o.b. *Colorado.*

Brilliant black, $32.90; seconds (mine run), $25.50.

Selects, $30.50, f.o.b. Utah. Nominal.

GRAPHITE—Per lb., f.o.b. *New York:* Ceylon lump, 6½@7½c.; carbon lump, 3@6c.; chip, 5@6c.; dust, 3@4c.; Madagascar flake, 5@6c.

No. 1 flake, 8@16c.; No. 2, 5½c. upward; fine ground, 55 to 70 per cent carbon, 3c. upward; amorphous, 3c. upward.

Crude amorphous graphite, $12@$23 per ton, according to grade.

GREENSAND — Per ton, f.o.b. cars, *New Jersey:* Screened and bagged, best grade, in carload lots, $20.

GYPSUM—Per ton, f.o.b. mill, crushed rock, *Iowa,* $2.50; *Ohio* and *New York,* $3. Ground, *Ohio,* $4; *Iowa,* $6. Agricultural, $6@$7. Calcined, $6@$9.

IRON OXIDE (See Ocher)—Per lb.: Standard Spanish red, 3@4½c.; domestic earth, 2@4½c.

KAOLIN—See China Clay.

KIESELGUHR—See Diatomite.

LEPIDOLITE—Per ton, $50@$60 for ordinary grades. Nominal.

LIMESTONE—Per ton, f.o.b. shipping points, depending on location, either lump or crushed, 25c.@$1.75.

Agricultural, $1 up to $6 per ton; as to grade and point of shipment.

MAGNESITE—Per ton, f.o.b. *California,* dead-burned, $25. Kiln run, 93 per cent MgO (artificial periclase), $68; 88 per cent MgO, $35. Caustic, 95 per cent MgO, $45; 90 per cent, $40. *Washington:* Dead-burned grain magnesite, $22.

MICA—Per ton, f.o.b. *New Mexico,* scrap, white, $21; off color, $18. Punch, white, for disks, per lb., 10c.; for washers, 8c.

Per ton, f.o.b. *New Hampshire,* roofing mica, $23; snow, $34; 40 mesh white, $40; 60 mesh, $48; 100 mesh, 60; 200 mesh, $75. Clean dry mixed bench and mine scrap, $13.

Per lb., f.o.b. *North Carolina:* Punch, 3@5c.; 1½x2 in., 20@30c.; 2x2, 30@50c.; 2x3, 60@90c.; 3x3, $1 @$1.40; 3x4, $1.40@$1.80; 3x5, $1.50 @$2; 4x6, $2.25@$3; 6x8, $2.50@ $3.75; 8x10, $5@$7.50. These prices apply both to No. 1 and No. 2 mica.

Black-stained mica takes a discount of 10 to 25 per cent from this schedule. White North Carolina mica, 70 mesh, $60 to $80. Biotite, or black mica, $15 a ton, unground.

MINERAL BLACK—(Graphitic shale)—Per ton, 325 mesh, 75 per cent carbon. $22.50, f.o.b. *Virginia.*

MONAZITE—Per ton, minimum 6 per cent ThO_2, $60.

OCHER—Per ton, f.o.b. *Georgia* mines, $17.50 in sacks; $21 in barrels. Buff clay, 98 per cent through 325 mesh, $18.

F.o.b. *Virginia,* dark yellow, 300 mesh, 60 per cent ferric oxide, in jute bags, $19.50.

PHOSPHATE—Per long ton, f.a.s. or f.o.b. mines:

Florida, pebble, f.a.s., for export: 76@77 per cent, $7.15; 75 per cent, $6.40; 74@75 per cent, $6.15; 70 per cent, $4.65; 68 per cent, $4.10.

Florida, pebble, domestic: 76@77 per cent, $6.50; 74@75 per cent, $5.50; 72 per cent, $4.50; 70 per cent, $4.

Tennessee, ground lime phosphate, 80 per cent through 300 mesh, 33 per cent P_2O_5, $12.80 per net ton, bags extra. Rock phosphate, 29 per cent P_2O_5, 200 mesh, $9.50. Furnace lump $6.25.

PUMICE STONE—Per lb., in barrels, powdered, 2½@4c.; lump, 5@7c.

PYRITES—Per long ton unit of sulphur, c.i.f. United States ports, guaranteed 48 per cent sulphur, Spanish, 13c.

POTASH—Per ton, contracts:

	Bags	Bulk
Muriate of potash, 80@85 per cent, basis 80 per cent	$37.15	$35.55
Sulphate of potash, 90@95 per cent, basis 90 per cent	48.25	46.65
Sulphate of potash-magnesia, 48@53 per cent, basis 48 per cent	27.80	26.20
Manure salt, 30 per cent	22.15	19.15
Manure salt, 20 per cent	15.65	12.65
Kainit, 14 per cent	12.70	9.70

Prices are delivered to Atlantic ports. Discounts up to 4 per cent for early shipment. Spot prices, $1.25@$1.50 per ton higher than on contract.

[1]QUARTZ ROCK CRYSTALS—For fusing, all sizes, $250 per ton. Prisms for piezo-electrical and optical use command premium.

SILICA—Per ton, water ground and floated, in bags, f.o.b. *Illinois:* 325 mesh, $16@$40 for 92 to 99½ per cent grades. Dry ground, air-floated, 325 mesh, 92@99½ per cent silica, $14@$30. Glass sand f.o.b. producing plant, $1.25@$5 per ton; molding sand, 50c.@$3.50; blast sand, $1.75@$6. *California:* $5 for quartz and $2.50 for sand.

[1]STRONTIANITE—Per ton, lump in carload lots, minimum 90@92 per cent $SrCO_3$, $100.

SULPHUR—Per long ton for domestic market, $18 f.o.b. Texas mines.

TALC—Per ton, carload lots, f.o.b. works, containers included unless otherwise specified:

New Jersey: Soapstone, ground, $10 @$12.

New York: Double air floated, short fiber, 200 mesh, $13.75; 325 mesh, $14.75.

Vermont: 99 per cent through 200 mesh, extra white, bulk basis, $7.50@$8; 97 to 98 per cent through 200 mesh, medium white, $6.50@$7. Packing in paper bags, $1 per ton extra.

Virginia: 200 mesh, $4.60@$7.25, 325 mesh, $8.75@$10.50.

TRIPOLI — Per ton, burlap bags, paper liners, minimum carload 30 tons, f.o.b. *Missouri:* Once ground through 40 mesh, rose and cream colored, $15. Double ground through 110 mesh, rose and cream, $17. Air-floated through 200 mesh, rose and cream, $22.50.

Metallic Compounds

ARSENIOUS OXIDE (White arsenic)—Per lb., 4c., delivered, all positions.

CALCIUM MOLYBDATE OR MOLYTE—Per lb. of contained Mo, 85c.

COBALT OXIDE—Per lb., black oxide, 70@71 per cent grade, $1.35.

COPPER SULPHATE (Blue Vitriol)—Per lb., in car lots, 3.10c. for either large or small crystals.

SODIUM NITRATE—Per 100 lb., crude natural, in bags ex vessel, Atlantic ports, $1.77.

SODIUM SULPHATE (Salt Cake)—Per ton, bulk, f.o.b. works, $16@$18.

ZINC OXIDE—Per lb. in bags, in car lots: Lead-free, 6½c.; 10, 20 or 35 per cent leaded grades, 6¼c.; French red seal, in bags, 9⅜c.

ZIRCONIUM DIOXIDE—Per lb. in 100- to 500-lb. lots, 87 per cent ZrO_2, commercial, 50c.

Refractories

CHROME BRICK—Per ton, f.o.b. shipping point, $42.50. Grecian refractory ore, 37@42 per cent, 40c. per unit.

FIRECLAY BRICK—Per M., first quality, $38, *Ohio, Kentucky, Central Pennsylvania;* second quality, $25@$30.

MAGNESITE—Brick, per ton, f.o.b. works, 9-in. straights, $65. Dead-burned grain, $40, f.o.b. Chester, Pa., or Baltimore.

SILICA BRICK—Per M., *Pennsylvania,* $38; *Alabama,* $50; *Illinois* and *Indiana,* $47.

ZIRKITE—Per lb., powdered, 65@70 per cent ZrO_2, 3½c. Brick, straights, 80c.@$1 each.

Rolled Metals

COPPER—Per lb., sheets, hot-rolled, 15⅞c.; wire, f.o.b. mill 8½c.

LEAD SHEETS—Per lb., full rolled, 7c.; clipped, 7¼c.

MONEL METAL—Per lb., sheets, full finished, 42c.; strip, cold-rolled, 45c.; rods, hot-rolled, 35c.

MUNTZ METAL—Per lb. rods, 11⅛c.; sheets, 15c.

NICKEL—Per lb., sheets, full finished. 52c.; rods, hot-rolled, 45c.

NICKEL SILVER—Per lb., sheets, 10 per cent, 21@21⅜c.; 18 per cent, 24½ @24⅞c. Wire and rods, 10 per cent, 24½c.; 15 per cent, 28½c.; 18 per cent, 32c.

PHOSPHOR BRONZE—Per lb., sheets and rods, 5 per cent tin, 26⅝c.; wire, 5 per cent, 27⅛c.; 10 per cent, 31⅝c.

ZINC SHEETS—Per lb., 9c., f.o.b. works; ribbon, 8½c.; 7 per cent discount on orders for 18 tons or more.

Alloys

BERYLLIUM-COPPER—Per lb., containing 12.5 per cent of Be, $6.35.

FERROCHROME—Per lb. of contained chromium, 4 to 6 per cent carbon, 65 to 70 per cent chromium, 10c., delivered, on contracts; spot, 10½c. Containing 2 per cent carbon, 67 to 72 per cent chromium, spot, 17c.; maximum 0.10 per cent carbon, 25c., spot; 23½c. contracts.

FERROMANGANESE—Per gross ton, furnace: domestic and foreign, 78@82 per cent, $72@$75, contracts, depending on quantity. Spiegeleisen, 19@21 per cent, $26@$27 for spot carloads.

FERROMOLYBDENUM—Per lb. of Mo, f.o.b. shipping point, 50@60 per cent Mo, $1.

FERROPHOSPHORUS—Per gross ton, 18 per cent P, $91; electrolytic, 24 per cent, $122.50, f.o.b. *Alabama* and *Tennessee.*

FERROSILICON—Per gross ton, delivered, 50 per cent, $77.50; 75 per cent, $126; 14@16 per cent, $31, f.o.b. Niagara Falls, N. Y. Spot shipments $5@$10 per ton higher on 50 and 75 per cent grades.

FERROCARBONTITANIUM — Per ton, $140, f.o.b. producer's plant, carlots.

FERROTUNGSTEN—Per lb. of W contained, 75@80 per cent W, $1@$1.10, f.o.b. works.

FERROVANADIUM—Per lb. of V contained, delivered, $3.05@$3.30.

SILICOMANGANESE — Per long ton, carload contracts, delivered, $105 for maximum 2½ per cent carbon; $115 for maximum 1 per cent carbon.

SILICON ZIRCONIUM—Per lb., 47@52 per cent Si, 35@40 per cent Zr, 16@19c.

ZIRCONIUM FERROSILICON—Per gross ton, 12@15 per cent Zr, 39@43 per cent Si, $103.50@$108.50.

Iron, Steel, and Coke

IRON—Per gross ton, Valley furnaces: Bessemer, $16@$16.50; basic, $15; and No. 2 foundry, $15.50@$16.

STEEL—Per gross ton, base prices, Pittsburgh, billets and slabs, $27; bars, plates, and structural shapes, per 100 lb., $1.50@$1.60.

COKE—Per ton, Connellsville furnace, $2.25@$2.35. Connellsville foundry, $3.25@$4.25. Birmingham furnace, $3.50@$4.50. Byproduct coke, Ohio and Kentucky (Connellsville basis), $5.50; Buffalo and Detroit, $8@$8.50; Birmingham foundry, $5.

[1]Price furnished by Foote Mineral Company, Philadelphia.

Daily Prices of Metals

For the month of January, 1932

United States Market

Jan.	Electrolytic Copper, Refinery	Straits Tin, New York	Lead—New York	Lead—St. Louis	Zinc St. Louis
1		Holiday			
2	7.025	21.600	3.75	3.55	3.075@3.125
4	7.025	21.100	3.75	3.55	3.125
5	7.025	20.625@20.80	3.75	3.55	3.10
6	7.025	21.125	3.75	3.55	3.10
7	7.025	21.55 @21.75	3.75	3.55	3.05 @3.10
8	7.025	21.65 @21.875	3.75	3.55	3.075
9	7.025	21.875	3.75	3.55	3.075
11	7.025	21.750	3.75	3.55	3.05 @3.075
12	7.275	21.80 @21.875	3.75	3.55	3.05 @3.075
13	7.275	21.700	3.75	3.55	3.05
14	7.025@7.275	22.000	3.75	3.55	3.05
15	7.025@7.275	22.250	3.75	3.55	3.00
16	7.025@7.275	22.250	3.75	3.55	3.00
18	7.025@7.275	22.05 @22.10	3.75	3.55	3.00
19	7.025@7.275	22.050	3.75	3.55	3.00
20	7.025@7.275	22.20 @22.25	3.75	3.55	3.00
21	7.025@7.275	22.15 @22.25	3.75	3.55	3.00
22	7.025@7.275	21.75 @21.875	3.75	3.55	3.00
23	7.025@7.275	21.75 @21.875	3.75	3.55	2.95 @3.00
25	7.025@7.275	21.75 @21.875	3.75	3.55	2.95 @3.00
26	7.025@7.275	22.125@22.25	3.75	3.55	2.875@2.90
27	7.025@7.275	22.000	3.75	3.55	2.90
28	6.525@6.775	21.800	3.75	3.55	2.90
29	6.525@6.775	21.750	3.75	3.55	2.90
30	6.525@6.775	21.750	3.75	3.55	2.825@2.875
Av. for Month	7.060	21.804	3.750	3.550	3.011
Jan.		Averages for E. & M. J. Week			
6	7.025	21.248	3.750	3.550	3.113
13	7.108	21.763	3.750	3.550	3.067
20	7.150	22.142	3.750	3.550	3.008
27	7.150	21.971	3.750	3.550	2.956
Jan.		Calendar Week Averages			
2	7.025	21.715	3.750	3.550	3.133
9	7.025	21.371	3.750	3.550	3.092
16	7.171	21.965	3.750	3.550	3.038
23	7.150	22.029	3.750	3.550	2.996
30	6.900	21.883	3.750	3.550	2.902

Silver, Gold, and Sterling Exchange New York and London

Jan.	Sterling Exchange "90-Day" "Checks"	Sterling Exchange "90-Day" Demand	Silver New York	Silver London	Gold, London
1		Holiday		20.1875	122s 7d
2	339.75	339.25	30.375	20.3125	.....
4	336.50	335.50	30.250	20.3750	122s 2d
5	335.50	334.75	30.250	20.4375	122s 5d
6	335.00	334.00	29.625	20.1875	122s 9d
7	338.00	337.00	29.750	19.8125	121s 8d
8	340.00	339.00	30.125	19.9375	120s 4d
9	339.50	338.50	29.875	19.8750	.....
11	338.00	337.25	29.875	20.0000	121s 11d
12	340.25	339.50	30.000	19.9375	121s 4d
13	339.75	339.00	29.875	19.8125	120s 9d
14	345.25	344.50	30.375	19.9375	120s 4d
15	348.00	347.25	30.250	19.6250	117s 11d
16	348.25	347.75	29.875	19.3125	.....
18	346.50	346.50	29.500	18.9375	118s 8d
19	344.50	344.00	29.500	19.0625	120s ..
20	345.75	345.25	29.500	18.9375	120s ..
21	345.00	345.00	29.625	19.1250	119s 5d
22	344.00	344.00	29.875	19.5000	119s 8d
23	343.25	343.25	29.500	19.4375	.....
25	343.625	343.625	29.500	19.5000	120s 9d
26	345.25	345.25	29.500	19.3125	119s 3d
27	345.50	345.50	29.250	19.1250	119s 9d
28	346.00	346.00	29.250	19.0625	119s 3d
29	345.25	345.25	29.250	19.1250	119s 7d
30	344.50	344.50	29.750	19.3125	.....
Av. for Month	342.515	.....	29.780	19.623	.....
Jan.		Averages for E. & M. J. Week			
6	336.950	.....	30.150	.....	.....
13	339.250	.....	29.917	.....	.....
20	346.375	.....	29.833	.....	.....
27	344.438	.....	29.542	.....	.....

Calendar week averages: New York Silver, January 2nd, 30.275c.; 9th, 29.979c.; 16th, 30.042c.; 23rd, 29.583c.; 30th, 29.417c.

London Market

Jan.	Copper—Standard—Spot	Copper—Standard—3 Mo.	Copper—Electrolytic (Bid)	Tin—Spot	Tin—3 Mo.	Lead—Spot	Lead—3 Mo.	Zinc—Spot	Zinc—3 Mo.
1					Holiday				
4	37.5625	38.0625	45.50	139.250	142.500	15.0625	15.1875	14.3125	14.8125
5	37.9375	38.3750	45.50	136.875	139.875	15.1250	15.1875	14.3125	14.7500
6	38.6250	39.0000	45.50	137.500	140.500	15.1875	15.2500	14.3750	14.8125
7	39.3750	39.7500	47.00	140.375	143.375	15.3750	15.3750	14.5625	15.0000
8	39.1250	39.4375	47.00	141.125	144.250	15.3125	15.3750	14.6250	15.0625
11	41.1250	41.2500	47.50	142.625	145.750	15.5625	15.6250	14.6875	15.1250
12	42.7500	42.5000	49.00	142.625	145.750	15.6250	15.6250	14.6875	15.1875
13	42.1250	41.8750	48.50	142.125	145.125	15.5000	15.5000	14.5625	15.0625
14	41.2500	41.2500	47.00	141.000	144.250	15.3125	15.3750	14.5625	15.0000
15	40.7500	40.7500	47.00	141.750	144.875	15.3125	15.3125	14.6875	15.0625
18	39.7500	39.7500	46.50	140.500	143.625	15.1875	15.1875	14.4375	14.8125
19	39.2500	39.3750	46.50	140.750	143.750	14.9375	14.9375	14.2500	14.6250
20	39.7500	39.7500	46.50	141.500	144.500	15.0625	15.0625	14.5000	14.8125
21	39.3750	39.4375	45.50	141.375	144.375	14.8125	14.8750	14.4375	14.8125
22	38.6875	38.8750	45.00	140.125	143.125	14.8125	14.8125	14.3125	14.6875
25	38.7500	39.0000	45.00	138.750	141.750	14.8750	14.8750	14.3125	14.7500
26	39.0000	39.1250	45.00	140.250	143.250	14.9375	15.0000	14.4375	14.8125
27	38.7500	38.8750	45.00	139.750	142.625	14.8125	14.8750	14.3125	14.7500
28	38.0000	38.1250	45.00	138.375	141.250	14.5000	14.6250	14.1250	14.5000
.....	37.2500	37.3750	44.50	137.750	140.500	14.3750	14.5000	13.8125	14.2500
Average for Mo.	39.459	.....	46.200	140.219	.....	15.084	15.128	14.416	14.834

The United States quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices are in cents per pound.

Copper, lead, and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted at 0.35c. per pound above St. Louis, this being the freight differential. Contract prices for High-Grade zinc delivered in the East and Middle West are 1c. above St. Louis prices for Prime Western.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

London prices for lead and zinc are the official prices for the morning session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

New York silver quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, basis of 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command a premium.

Monthly Average Prices of Metals

(See daily price table for basis of quoting)

Silver and Sterling Exchange

	New York		London Spot		Sterling Exchange	
	1931	1932	1931	1932	1931	1932
January	29.423	29.780	13.810	19.623	485.260	342.515
February	26.773	.....	12.432	.....	485.551	.....
March	29.192	.....	13.524	.....	485.596	.....
April	28.279	.....	13.120	.....	485.764	.....
May	27.650	.....	12.858	.....	486.188	.....
June	27.250	.....	12.707	.....	486.291	.....
July	28.255	.....	13.197	.....	485.349	.....
August	27.524	.....	12.815	.....	485.284	.....
September	28.180	.....	14.101	.....	451.245	.....
October	29.538	.....	17.153	.....	388.029	.....
November	32.223	.....	19.393	.....	371.130	.....
December	30.120	.....	20.023	.....	336.798	.....
Year	28.700	.....	14.594	.....	452.707	.....

New York quotations, cents per ounce troy, 999 fine. London, pence per ounce, sterling silver, 925 fine. Sterling exchange in cents.

Copper

	F.O.B. Refinery		London Spot			
	Electrolytic		Standard		Electrolytic	
	1931	1932	1931	1932	1931	1932
January	9.838	7.060	44.938	39.459	47.524	46.200
February	9.724	.....	45.372	.....	47.950	.....
March	9.854	.....	44.818	.....	47.699	.....
April	9.392	.....	42.694	.....	45.375	.....
May	8.665	.....	38.897	.....	42.175	.....
June	8.025	.....	35.827	.....	38.966	.....
July	7.698	.....	34.402	.....	37.293	.....
August	7.292	.....	32.572	.....	35.388	.....
September	6.988	.....	31.503	.....	36.148	.....
October	6.775	.....	34.957	.....	41.000	.....
November	6.558	.....	35.854	.....	41.190	.....
December	6.580	.....	38.273	.....	44.409	.....
Year	8.116	.....	38.342	.....	42.093	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Lead

	New York		St. Louis		London			
	1931	1932	1931	1932	1931 Spot	1931 3 Mos.	1932 Spot	1932 3 Mos.
January	4.802	3.750	4.604	3.550	13.872	13.905	15.084	15.128
February	4.552	.....	4.340	.....	13.444	13.550	.....	.....
March	4.527	.....	4.276	.....	13.128	13.355	.....	.....
April	4.412	.....	4.164	.....	12.375	12.606	.....	.....
May	3.818	.....	3.651	.....	11.491	11.778	.....	.....
June	3.917	.....	3.761	.....	11.582	11.952	.....	.....
July	4.400	.....	4.225	.....	12.731	12.899	.....	.....
August	4.400	.....	4.225	.....	11.944	11.994	.....	.....
September	4.400	.....	4.217	.....	11.932	12.026	.....	.....
October	3.964	.....	3.773	.....	13.227	13.270	.....	.....
November	3.937	.....	3.758	.....	14.577	14.491	.....	.....
December	3.792	.....	3.592	.....	15.188	15.361	.....	.....
Year	4.243	.....	4.049	.....	12.958	13.099	.....	.....

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Tin

	New York		London	
	1931	1932	1931	1932
	Straits		Spot	
January	26.137	21.804	115.798	140.219
February	26.315	.....	117.919	.....
March	27.065	.....	121.852	.....
April	25.222	.....	112.775	.....
May	23.221	.....	104.331	.....
June	23.478	.....	104.966	.....
July	24.978	.....	111.478	.....
August	25.738	.....	114.875	.....
September	24.618	.....	117.813	.....
October	22.723	.....	126.932	.....
November	22.779	.....	132.857	.....
December	21.328	.....	138.909	.....
Year	24.467	.....	118.375	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St. Louis		London			
	1931	1932	1931 Spot	1931 3 Mos.	1932 Spot	1932 3 Mos.
January	4.035	3.011	12.747	13.113	14.416	14.834
February	4.012	.....	12.303	12.694	.....	.....
March	4.002	.....	12.190	12.676	.....	.....
April	3.717	.....	11.353	11.838	.....	.....
May	3.306	.....	10.484	10.875	.....	.....
June	3.416	.....	11.270	11.750	.....	.....
July	3.893	.....	12.280	12.802	.....	.....
August	3.817	.....	11.444	12.028	.....	.....
September	3.744	.....	11.571	12.063	.....	.....
October	3.377	.....	12.733	13.216	.....	.....
November	3.209	.....	13.845	14.247	.....	.....
December	3.149	.....	14.361	14.818	.....	.....
Year	3.640	.....	12.215	12.677	.....	.....

St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Cadmium and Aluminum

	Cadmium		Aluminum	
	1931	1932	1931	1932
January	67.115	55.000	23.300	23.300
February	55.000	.....	23.300	.....
March	55.000	.....	23.300	.....
April	55.000	.....	23.300	.....
May	55.000	.....	23.300	.....
June	55.000	.....	23.300	.....
July	55.000	.....	23.300	.....
August	55.000	.....	23.300	.....
September	55.000	.....	23.300	.....
October	55.000	.....	23.300	.....
November	55.000	.....	23.300	.....
December	55.000	.....	23.300	.....
Year	56.010	.....	23.300	.....

Aluminum in cents per pound, 99 per cent grade.
Cadmium, cents per pound.

Antimony, Quicksilver, and Platinum

	Antimony (*a*) New York		Quicksilver (*b*) New York		Platinum (*c*) New York	
	1931	1932	1931	1932	1931	1932
January	7.317	5.976	103.000	64.900	36.000	40.000
February	7.069	.....	100.205	.....	34.000	.....
March	7.127	.....	100.423	.....	29.538	.....
April	6.888	.....	102.077	.....	26.346	.....
May	6.524	.....	101.140	.....	24.980	.....
June	6.342	.....	92.058	.....	37.115	.....
July	6.802	.....	85.808	.....	40.000	.....
August	6.596	.....	80.115	.....	40.000	.....
September	6.542	.....	76.300	.....	40.000	.....
October	6.517	.....	72.385	.....	40.000	.....
November	6.679	.....	68.587	.....	40.000	.....
December	6.231	.....	66.115	.....	40.000	.....
Year	6.720	.....	87.351	.....	35.665	.....

(*a*) Antimony quotations in cents per pound, for ordinary brands. (*b*) Quicksilver in dollars per flask of 76 lb. (*c*) Platinum in dollars per ounce troy.

Pig Iron[1]

	Bessemer		Basic		No. 2 Foundry	
	1931	1932	1931	1932	1931	1932
January	17.50	16.00	17.00	15.00	17.00	15.50
February	17.29	.....	16.79	.....	16.79	.....
March	17.00	.....	16.50	.....	16.50	.....
April	17.00	.....	16.50	.....	16.50	.....
May	17.00	.....	16.38	.....	16.44	.....
June	17.00	.....	15.50	.....	16.00	.....
July	17.00	.....	15.50	.....	16.00	.....
August	17.00	.....	15.50	.....	16.00	.....
September	17.00	.....	15.50	.....	16.00	.....
October	16.92	.....	15.42	.....	16.00	.....
November	16.50	.....	15.00	.....	16.00	.....
December	16.25	.....	15.00	.....	15.75	.....
Year	16.96	.....	15.88	.....	16.25	.....

Iron in dollars per long ton. [1]F.o.b. Mahoning and Shenango Valley furnaces; freight to Pittsburgh, $1.76.

Mining Share Prices—Month of January, 1932

Company Name	High	Low	Last	§Most Recent Dividend
NEW YORK STOCK EXCHANGE				
Alaska Juneau	16⅛	11⅞	15	Ja. 9, Fe. 9, 1932 Q 0.12½
American Metal	6.62½	5.27½	5.27½	December, 1930 Q 0.25
Am. Metal, pfd	19½	16	17	Au. 22, Se. 1, 1931 Q 1.50
Am. Sm. & Ref	18	12½	15⅞	Ja. 15, Fe. 1, 1932 Q 0.12½
Am. Sm. & Ref. 2d pfd.	50½	41½	50½	Fe. 5, Mh. 1, 1932 Q 1.50
Am.Sm. & Ref. 1st pfd.	85	73	83	Fe. 5, Mh. 1, 1932 Q 1.75
Am. Zinc, L. & S.	3.37½	2.87½	2.87½	May, 1917 1.00
Am. Zinc, L. & S., pfd.	23	22	22	October, 1930 Q 1.50½
Anaconda	12⅜	9.00	10½	Jy. 11, Au. 17, 1931 Q 0.37½
Andes Copper	4.75	4.75	4.75	Ja. 10, Fe. 9, 1931 Q 0.25
Butte C. & Z.	1.25	1.00	1.12½	December, 1929 0.50
Butte & Superior	0.75	0.62½	0.62½	December, 1929 Q 0.50
Callahan Zinc-Lead	0.50	0.37½	0.50	December, 1920 0.50
Cal. & Hecla	4.00	3.00	3.12½	June, 1930 0.50
Cerro de Pasco Copper	15	9.87½	12½	Ja. 14, Fe. 1, 1932 Q 0.25
Dome Mines	9.25	7.50	8.50	Mh. 31, Ap. 20, 1932 Q 0.25
Federal M. & S.	....	....	26*	June, 1927 10.00
Federal M. & S., pfd.	....	....	36*	My. 25, Je. 5, 1931 Q 1.75
Freeport Texas	19½	15½	17½	Fe. 15, Mh. 1, 1932 Q 0.50
Granby Con	7.75	5.62½	7.00	Ja. 15, Fe. 1, 1932 Q 0.12½
Greene Cananea	19	15	15	July, 1930 0.75
Homestake	130½	120	121½	Ja. 20, Ja. 26, 1932 Q 0.65
Howe Sound	16⅜	11⅛	13	De. 31, Ja. 15, 1932 Q 0.50
Inspiration	4.25	3.25	3.25	July, 1930 0.50
International Nickel	9.12½	7.12½	8.12½	De. 1, De. 31, 1931 Q 0.05
Int. Nickel, pfd.	85⅛	80⅛	82½	Ja. 2, Fe. 1, 1932 Q 1.75
Kennecott Copper	13	10	10⅜	De. 17, Ja. 2, 1932 Q 0.12½
McIntyre Porcupine	16½	14⅜	15⅜	Fe. 1, Mh. 1, 1932 Q 0.25
Magma Copper	8.75	7.25	7.25	De. 31, Ja. 15, 1932 Q 0.12½
Miami Copper	4.25	2.87½	3.50	August, 1930 0.375
Mother Lode	0.37½	0.25	0.25	June, 1930 0.10
National Lead	92	86	86	De. 11, De. 31, 1931 QX 1.50
National Lead, pfd. A.	118	113	115½	Ja. 15, Fe. 1, 1932 Q 0.62½
National Lead, pfd. B.	105	100	101½	Ja. 15, Fe. 1, 1932 Q 1.50
Nevada Con.	6.62½	5.12½	5.50	De. 17, De. 31, 1931 Q 0.10
Noranda Mines	15	12⅜	14	De. 15, De. 29, 1931 0.50
Park Utah Con.	1.25	1.12½	1.12½	July, 1929 Q 0.20
Patino M. & E.	7.50	6.12½	6.12½	December, 1929 4s.
Phelps Dodge	8.50	6.00	7.00	Je. 18, Jy. 1, 1931 Q 0.25
Rand Mines	....	....	20*	August, 1930 1.52
St. Joseph Lead	10½	7.50	10	Mh. 10, Mh. 21, 1932 Q 0.15
Seneca Copper	0.50	0.25	0.37½	....
Tennessee Corp.	2.62½	1.87½	2.00	Fe. 28, Mh. 16, 1931 Q 0.125
Texas Gulf Sulphur	25⅞	20⅛	23½	De. 1, De. 15, 1931 Q 0.75
U. S. S. R. & M.	17	14⅜	15⅞	De. 31, Ja. 15, 1932 Q 0.25
U. S. S. R. & M., pfd.	38½	36½	37½	De. 31, Ja. 15, 1932 Q 0.87½
Utah Copper	58½	45	45	De. 17, De. 31, 1931 Q 1.00
Vanadium Corp.	16¼	11½	13	Fe. 2, Fe. 16, 1931 Q 0.75
NEW YORK CURB EXCHANGE				
Aluminum Co. of Am.	61¾	45½	50¾	....
Alum. Co. of Am., pfd.	67½	60½	63½	De. 15, Ja. 1, 1932 Q 1.50
Anglo-Chilean Con.	0.62½	0.37½	0.50	4 shares Cosach B. June, 1931
Bunker H. & S.	24	22	22½	De. 31, Ja. 5, 1932 Q 1.50
Ca negie Metals	1.87½	0.25	0.25	....
Comstock Tunnel	0.43¾	0.25	0.43½	....
Con. Coppermines	1.25	0.87½	0.87½	....
Copper Range	3.12½	2.00	2.00	July, 1930 0.25
Cresson Consolidated	0.25	0.12½	0.25	Je. 30, Jy. 10, 1931 Q 0.01
Cusi Mexicana	0.43½	0.37½	0.37½	....
Evans-Wallower	0.43½	0.43½	0.43½	....
Federated Metals	6.00	5.25	5.50	Ja. 5, Ja. 15, 1931 Q 0.25
Hecla Mining	5.12½	4.50	5.00	No. 15, De. 15, 1931 Q 0.10
Hollinger Consolidated	4.62½	4.37½	4.62½	Ja. 14, Ja. 28, 1932 M 0.05
Hudson Bay M. & S.	2.25	2.00	2.12½	....
Iron Cap Copper	....	....	0.62½*	....
Mayflower Associates	28½	26½	26½	De. 1, De. 15, 1931 Q 0.50
Mining Corporation	1.12½	1.12½	1.12½	December, 1929 0.12½
New Jersey Zinc	28⅜	23	25⅛	Ja. 20, Fe. 10, 1932 Q 0.50
Newmont Mining	14½	9.87½	11⅛	Mh. 31, Ap. 15, 1931 Q 1.00
N. Y. & Honduras Ros.	13⅜	13⅛	13½	Ja. 19, Ja. 30, 1932 X 0.37½
Nipissing	1.00	0.87½	0.87½	Mh. 31, Ap. 20, 1931 Q 0.075
Ohio Copper	0.18¾	0.12½	0.12½	September, 1926 0.03
Premier Gold	0.56¼	0.50	0.50	De. 14, Ja. 4, 1932 Q 0.03
Quincy	....	....	2.00*	March, 1920 1.00
Shattuck Denn	....	....	1.62½*	....
So. Am. Gold & Plat.	0.62½	0.50	0.50	....
Teck-Hughes	4.50	4.00	4.00	Ja. 16, Fe. 1, 1932 Q 0.15
Tonopah Mining	0.37½	0.31½	0.31½	October, 1929 0.07½
United Eastern	....	....	0.06½*	....
United Verde Ex.	4.37½	3.75	3.62½	Ja. 2, Fe. 1, 1932 Q 0.25
Utah-Apex	0.50	0.50	0.50	Decem er, 1929 0.02
Yukon Gold	0.12½	0.12½	0.12½	June, 1918 0.02
BOSTON STOCK EXCHANGE				
Isle Royale	2.37½	2.37½	2.37½	March, 1930 0.50
Mohawk Mining	18	11¾	15½	Ja. 30, Mh. 1, 1932 Q 0.25
Old Dominion	1.25	0.90	0.90	December, 1918 1.00
Utah Met. & Tunnel	0.40	0.25	0.40	December, 1927 0.30
¶MONTREAL				
Asbestos Corp.	....	....	0.25*	January, 1926 1.50
Asbestos Corp., pfd.	....	....	2.00*	January, 1930 1.75
Consolidated M. & S.	71½	70½	70½	De. 23, Ja. 15, 1932. SAX 1.25

Company Name	High	Low	Last	§Most Recent Dividend
SPOKANE				
Constitution	....	....	*0.06¼	....
Dayrock	....	....	*0.95	March, 1930 0.03
Golconda	0.18½	0.18½	0.18½	July, 1929 0.02
Jack Waite Con.	0.22½	0.20	0.21	....
Los Lugos	....	....	*0.01¾	....
Mexican Premier	....	....	*0.08	January, 1930 0.01
Montana Mines	....	....	*0.09	....
Noble Five	....	....	*0.03	January, 1930 0.005
Pend Oreille	1.10	0.98	1.08	....
Sherman Lead	....	....	*0.27½	March, 1930 0.01
Sidney	....	....	*0.05	October, 1929 0.01
Sunshine Mining	1.19	1.12	1.12	De. 10, De. 23, 1931 X 0.02
Tamarack & Custer	0.15¼	0.15¼	0.15¼	September, 1924 0.25
SALT LAKE CITY				
Chief Con.	41	35	35	February, 1928 0.10
Combined Metals	8¼	5¼	5¼	....
Eureka Bullion	20	17½	17½	....
Eureka Lilly	12	10	10	....
Moscow Silver	0.40	0.30	0.30	....
New Quincy	6¼	3¾	4	September, 1929 Q 0.10
North Lily	74	67	67	January, 1930 0.15
Park Bingham	....	....	13*	....
Park City Con.	12½	10	10	....
Rico Argentine	3¾	3½	3½	December, 1929 0.03
Silver King Coalition	3.60	3.40	3.45	De. 20, Ja. 2, 1931 Q 0.15
Tintic Lead	98	67	77	....
Tintic Standard	3.12½	2.70	2.80	De. 10, De. 24, 1931 Q 0.10
Walker Mining	90	76	76	April, 1930 0.075
¶ TORONTO				
Abana Mines	0.05	0.04	0.05	....
Amulet Mines	0.22	0.19	0.19	....
Barry-Hollinger	0.11	0.07½	0.07½	....
Base Metals	1.00	0.90	0.90	....
Canam Metals	....	....	0.02*	....
Castle-Trethewey	0.16	0.14	0.14	....
Central Manitoba	0.08	0.07	0.07	....
Falconbridge	1.05	0.95	0.95	....
Granada Gold	1.25	1.04	1.04	....
Howey Mines	0.26	0.31½	0.35½	....
Keeley	0.24	0.23	0.23	March, 1928 0.04
Kirkland Lake	0.55	0.50	0.50	....
Lake Shore	29.10	27.00	28.75	De. 1, De. 15, 1931 QX 1.00
Sherritt Gordon	0.65	0.58	0.60	....
Siscoe Gold	0.61½	0.50	0.60½	....
Sylvanite	0.65	0.58	0.62	De. 5, De. 31, 1931 SA 0.02
Treadwell Yukon	1.30	0.90	1.12	....
Ventures	0.53	0.46	0.49	....
Vipond Con.	0.45	0.38	0.40	April, 1927 0.03
Waite-A.-M.	1.00	0.60	0.90	....
Wright-Hargreaves	3.06	2.70	2.87	De. 14, Ja. 2, 1932 QX 0.05
ST. LOUIS, CINCINNATI, AND DENVER				
Consolidated L. & Z.	....	....	1.50*	December, 1929 0.125
Eagle-Picher	5.00	4.87½	5.00	April, 1930 0.20
Eagle-Picher, pfd.	....	....	89*	De. 31, Ja. 15, 1931 Q 1.50
Empire Chief	0.01½	0.00¾	0.00¾	....
Star of Utah	0.15½	0.12	0.15	....
Tungsten Prod.	0.10½	0.07	0.07	....
Ute Gold	0.17½	0.12½	0.12½	....
SAN FRANCISCO, LOS ANGELES, AND COLORADO SPRINGS				
California Copper	0.25	0.25	0.25	....
(a)Golden Cycle	12	10	11	No. 30, De. 10, 1931 Q 0.40
(a)Granite Gold	0.18½	0.15	0.15	De. 23, Ja. 2, 1932 Q 0.01
Idaho-Maryland	1.86	1.26	1.81	....
Tom Reed	0.53	0.25	0.25	De. 15, Ja. 1, 1932 Q 0.03
(a) United Gold	0.05	0.03	0.05	Oct. 15, No. 1, 1931 0.01

‡LONDON

Company Name	High	Low	Last	Most Recent Dividend (Per Cent, Unless Noted)
Anglo American	7/10½	7/–	7/3	22½, Feb. 19. 1930
Aramayo Mines	15/6	15/6	15/6	5, Oct. 23, 1929
Burma Corporation	9/1½	8/3	8/9	1¼, Dec. 10, 1930(b)
Camp Bird	–/4½	–4/1½	–4½	16¼, April 25, 1928
Fresnillo	9/–	9/–	9/–	25 cents, Feb. 12, 1930
Frontino & Bolivia	16/10½	16/3	16/3	2½, July 1, 1931
Lake View & Star	8/9	7/6	8/1½	11½, 1921
Mexican Corporation	3/7½	3/–	3/6	10, Oct. 24, 1929
Oroville Dredging	2/4½	1/10½	2/–	37½, May 16, 1930
Rhokana Corporation	75/7½	60/–	62/6	....
Rhodes.-Select. Trust	6/10½	6/–	6/–	....
Rio Tinto	16⅛	12½	15½	10s, May 1, 1931
St. John del Rey	19/–	18/–	18/–	9d, No. 20, 1931
San Francisco Mines	9/7½	7/6	8/–	10, Jan. 7, 1931
Santa Gertrudis	7/–	6/3	6/3	9d., July 9, 1931
Selukwe	1/9	1/3	1/9	6¼, April 2, 1917
So. American Copper	–/9	–/6	–/7½	....
Tanganyika	20/6	16/10½	19/4½	2½, Aug. 2, 1930
Wiluna Gold	8/4½	7/6	8/–	....
Union Minière	3,825	3,050	3,615	240 francs, July, 1931

Salt Lake Stock Exchange courtesy J. A. Hogle & Company. ¶These figures are quoted in Canadian dollars. *Not traded in. †Belgian Francs. ‡The above London quotations are for the month ended Jan. 23. Q, quarterly; I, initial; M, monthly; X, extra; SA, semi-annual; L, liquidating B, plus bonus. §Total dividends paid during the month will be found tabulated in the Market and Financial News Section. Dates here given are those of closing of books and payment of dividend. (a) Bid prices. (b) 1¼% (2 annas) dividend, and bonus of ¼% (1 anna). (c) Closing bid prices. F.W., four weeks.